Figure 4-1 (left and right): Shared-use paths often serve as necessary and important extensions to the roadway network.

4. Shared-use Paths

Note: Photos are categorized by their content:

YES — *Positive example*

OK — *Special case example*

NO — *Not recommended.*

Shared-use paths are largely non-motorized facilities** most often built on exclusive rights-of-way with relatively few motor vehicle crossings. Properly used, shared-use paths are a complementary system of off-road transportation routes for bicyclists and others. They serve as a necessary extension of the roadway network. Shared-use paths should not substitute for on-road bicycle facilities, but, rather, supplement a system of on-road bike lanes, wide outside lanes, paved shoulders, and bike routes.

4.1 Shared-use path users, purposes, and locations

Shared-use paths support a wide variety of non-motorized travelers — bicyclists, in-line skaters, roller skaters, wheelchair users, walkers, runners, people with baby strollers or people walking dogs (fig. 4-2). Many state "rail trails" are open to snowmobile use during the winter. Shared-use paths are most commonly designed for two-way travel, and the guidance herein assumes two-way use unless otherwise stated.

Shared-use paths can serve a variety of important purposes:

- *a shortcut to a nearby destination or through a neighborhood;*
- *an alternative to a busy thoroughfare or a "motor vehicle-only" corridor;*
- *a way to get across a motorized barrier, especially a freeway;*
- *an enjoyable travel opportunity for individuals and families*
- *a place to exercise, recreate, or rehabilitate from injury.*

***There are many state trails in Wisconsin that permit snowmobile use. Motorized wheelchairs are allowed on most paths.*

To accomplish these ends, shared-use paths have been built:

- *along rivers, creeks, and lake fronts;*
- *on or next to railroad rights-of-way (abandoned or active), and utility easements;*
- *within college campuses or within and between parks; and*
- *between cul-de-sac streets in new developments.*

By analyzing barriers to non-motorized travel, popular corridors and destinations, and potential path opportunities, appropriate locations can be identified.

4.2 Designing paths and roads: differences and similarities

There are numerous similarities and differences between the design criteria for shared-use paths and highways. The designer should always be aware of these factors and how they influence the design of shared-use paths.

Similarities include the need for:

- *carefully designed vertical grades and curves;*
- *routine maintenance (e.g., joint filling);*
- *adequate curve radii;*
- *adequate sight distance at curves and intersections;*
- *warning, regulatory, and informational signs where required;*
- *basic pavement markings; and*
- *routine all-weather maintenance.*

Figure 4-2: Shared-use paths must accommodate a wide variety of users — young, old, bicyclists, tricyclists, pedestrians, wheel chair users, inline skaters, and more.

Differences include such things as:

- *vehicle size and clearance requirements;*
- *wide variety of bicycle user ages and capabilities;*
- *design speeds used to determine geometrics;*
- *grades that bicycles and motor vehicles can typically negotiate; and*
- *pavement structure needed to support typical path vs. road traffic.*

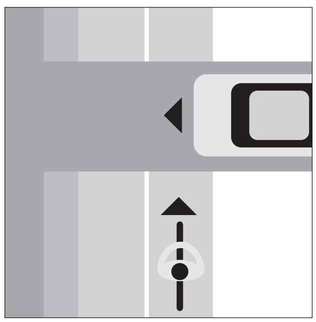
The remainder of this section provides guidance on each factor that should be considered in designing safe and functional shared-use paths.

4.3 Shared-use paths next to roadways

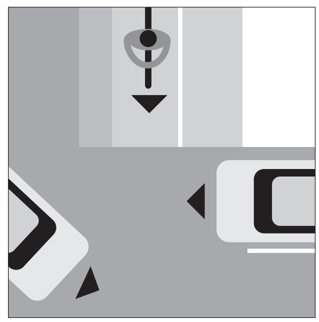
Separated shared-use paths (bicycle paths) are options primarily along river grades, lake fronts, or abandoned or shared rail corridors; they may also connect subdivisions and cul-de-sacs. Paths next to urban and suburban roadways pose operational problems and often increase the hazards to bicyclists. This section summarizes problems with paths adjacent to roadways. In some cases, paths along highways for short sections are permissible, given an appropriate level of separation between facilities.

4.3.1 Problems with paths next to roadways (sidepaths):

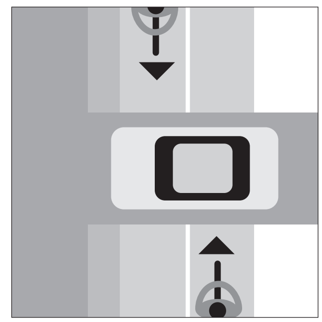
1. Cross-Street and Driveway Conflicts



Motorists may *think* bicyclists have to stop at all cross-streets or driveways.



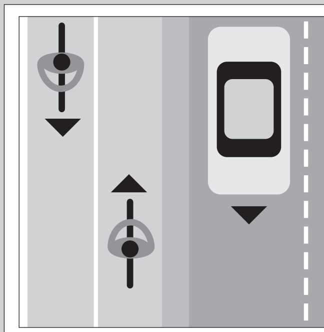
Motorists crossing the path may not even notice it — or the contraflow bicyclists.



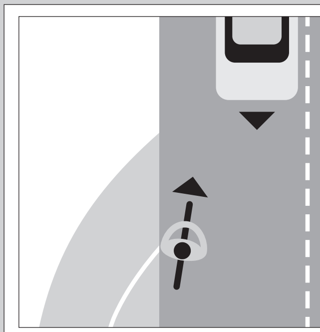
Stopped motor vehicles on side streets or driveways may block the path.

Most bicycle-motor vehicle crashes occur at intersections of roads or of roads and driveways; paths should not aggravate the problem.

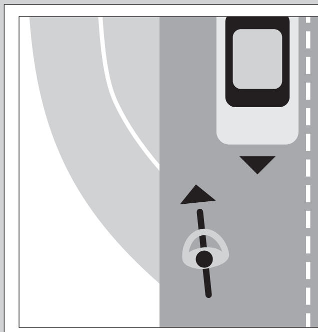
2. Encouragement of Wrong-Way Bicycling



One direction of bicyclists must ride against traffic.



At path's end, bicyclists going against traffic may continue riding wrong way.

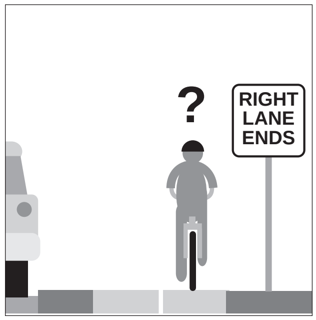


To get to a path entrance, bicyclists may ride against traffic or make unanticipated crossings..

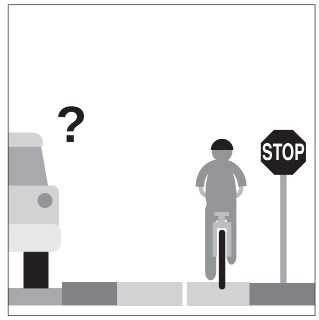
Wrong-way bicycling is a major cause of bicycle/motor vehicle crashes and should be discouraged at every opportunity.

3. Visibility and Applicability of Traffic Controls

The traffic signals and signs will be backwards for the contra-flow bicycle traffic.



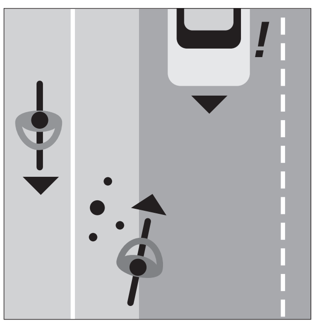
The road-oriented traffic signs may cause bicyclists confusion.



The path-oriented traffic signs may cause motorists confusion.

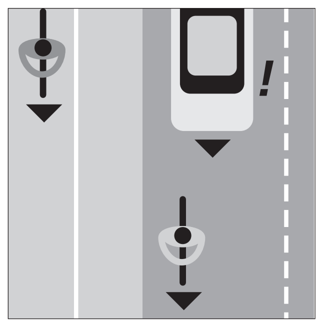
Two-way path traffic on one side of the roadway can make traffic controls more confusing to both bicyclists and motorists.

4. Maintenance and Limits on Available Space



Contraflow bicyclists may swerve into the road to avoid debris or wayward path users.

Barriers, while needed in tight spaces, can narrow both roadway and path and create hazards.



Some bicyclists may find the road cleaner, safer, and more convenient, frustrating some motorists.

Maintenance problems and inadequate space can add to the potential hazards of paths next to roadways.

For the above reasons, other types of bikeways are likely to be better suited to accommodate bicycle traffic along highway corridors, depending upon traffic conditions. Shared-use paths should **not** be considered a substitute for street improvements. Even where the path is located adjacent to the highway, many bicyclists will avoid it. They may find it less convenient, difficult to access from the direction they are traveling, and, perhaps, even unsafe at their speed to ride on these paths compared with the streets, particularly for utility trips.

Figure 4-3: A path next to an arterial street. Bicyclists on the path are required to stop at each minor cross street.

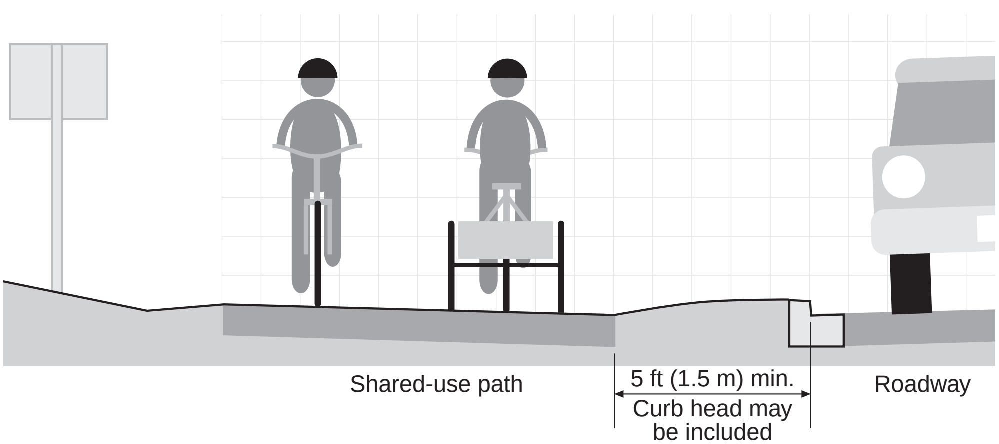
The path should have the same priority through intersections as the parallel highway (see Wisconsin State Statute 346.803(1)(b), Appendix C). Requiring or encouraging bicyclists to yield or stop at each cross-street or driveway (fig. 4-3) is inappropriate and frequently ignored. Excessive and improper traffic controls breed disrespect for ALL traffic controls on trails, even where clearly warranted.

If the right-of-way is too narrow to accommodate all highway and shared-use path features, consideration may be given to reducing existing or proposed widths of the various highway (and bikeway) elements (i.e., lane and shoulder widths, etc.). But reductions to less than applicable design criteria must be documented by an engineering analysis.

If a two-way shared-use path must be located adjacent to a roadway, a wide separation between the path and the adjacent highway (fig. 4-4) is desirable to demonstrate that the path functions as an independent facility for bicyclists and others. Additionally, the inside bicyclist will be riding directly opposed to oncoming motor vehicle traffic. This often increases average closing speeds by up to 30 mph (compared to bicyclists riding with traffic).

Figure 4-4: A minimum 5ft. (1.5 m) shoulder is required between roadway and shared-use path, unless a barrier is provided.

The minimum separation is 5 ft. (1.5 m) between the edge of the shoulder and the path (fig. 4-4); preferably, the path should be located outside of the roadway's clear zone. When the 5-ft. separation is not possible, a suitable physical barrier is recommended (fig. 4-5). Such barriers prevent path users and motorists from making unwanted movements between the path and the highway shoulder (and vice versa) and reinforce the concept that the path is an independent facility. Where a barrier or a space separation is not possible narrowing the 5 ft. of separation area to 3 ft. for a short distance (several hundred feet) is acceptable. [This may be necessary at intersection approaches.] Three feet of separation for a longer stretch would be permitted if the path is next to a wide shoulder or bike lane.



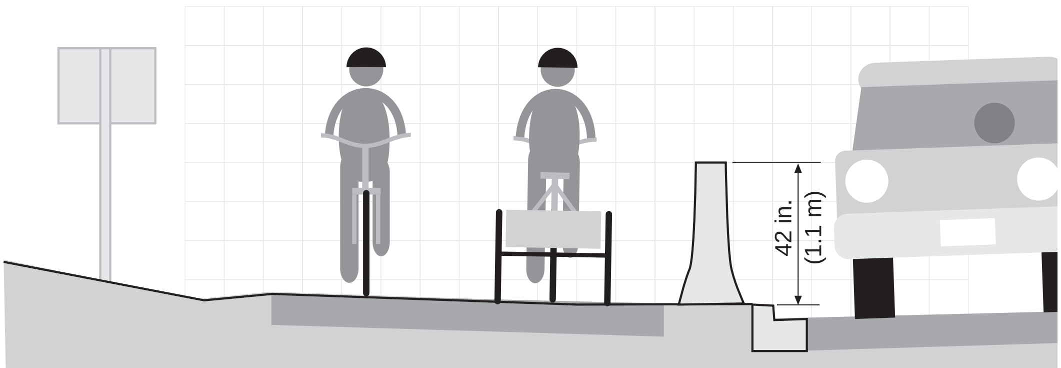


Figure 4-5: Where separation distance between the path and the roadway is inadequate, a barrier should be installed.

Where used, the vertical barrier should be a minimum of 42 in. (1.1 m) high in nearly all situations to prevent bicyclists from toppling over, unless the roadway has a shoulder or bicycle lane along with slow speeds and low volumes. A barrier between a shared-use path and adjacent highway should not impair sight distance at intersections, and should be designed to not be a hazard to errant motorists.

4.3.2 Sidewalk bikeways

Some early bikeway systems used sidewalks for both pedestrians and bicyclists. In general, this practice should be avoided since the design speed for a sidewalk is significantly less than for a shared-use path. In rare instances such facilities may be necessary, or desirable (i.e., for use by small children or on a bridge; see Section 2.9 for more information on bridges). Sidewalks are generally not suited for cycling for numerous reasons:

- *bicyclists face conflicts with pedestrians;*
- *sidewalks harbor hazards like utility poles, sign posts, benches, etc.;*
- *bicyclists face conflicts at driveways, alleys, and intersections; on sidewalks, they are often not visible to motorists and emerge unexpectedly. This is especially true if they ride against adjacent motor vehicle traffic: drivers do not expect vehicles on the wrong side; and*
- *bicyclists are put into awkward situations at intersections where they cannot safely act like vehicle drivers but are not in the pedestrian flow either, creating confusion for other road users.*

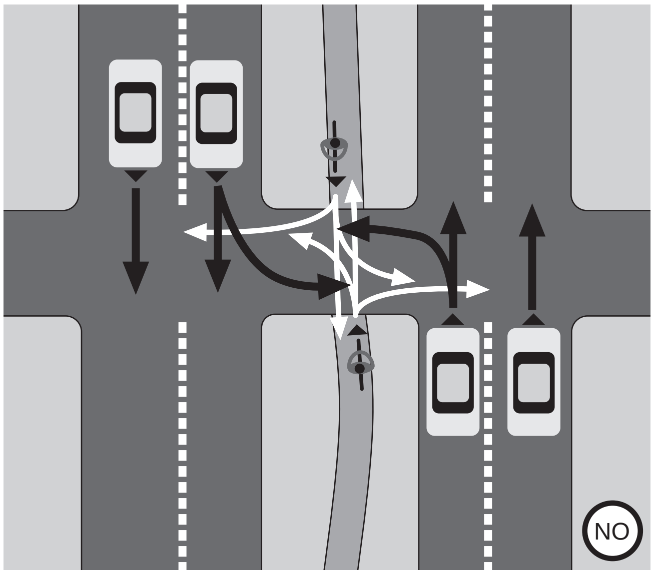
Figure 4-6: Designating sidewalks as bikeways ensures conflicts with the sidewalk's legitimate users.

Over all, bicyclists are safer when allowed to use the roadway as vehicle operators, rather than using the sidewalk as pedestrians. Where constraints do not allow full-width walkways and on-road bicycle lanes, solutions should be sought to create space for bicyclists AND pedestrians (e.g. by narrowing or eliminating motor vehicle lanes or on-street parking). In some urban situations, preference may be given to accommodating pedestrians. Sidewalks should not be signed for bicycle use — the choice should be left to the users. Wisconsin state statutes prohibit bicycling on sidewalks unless permitted by local ordinance on a community-wide or selective basis for certain sidewalk segments.

4.3.3 Shared-use paths in roadway medians

As a general rule, shared-use paths in the medians of highways, expressways, or boulevards are not recommended (fig. 4-7). They require bicyclists to operate in ways contrary to the normal rules of the road. Specific problems with such facilities include:

Figure 4-7 Some of the possibilities for bicycle-motor vehicle conflicts created by a median shared-use path



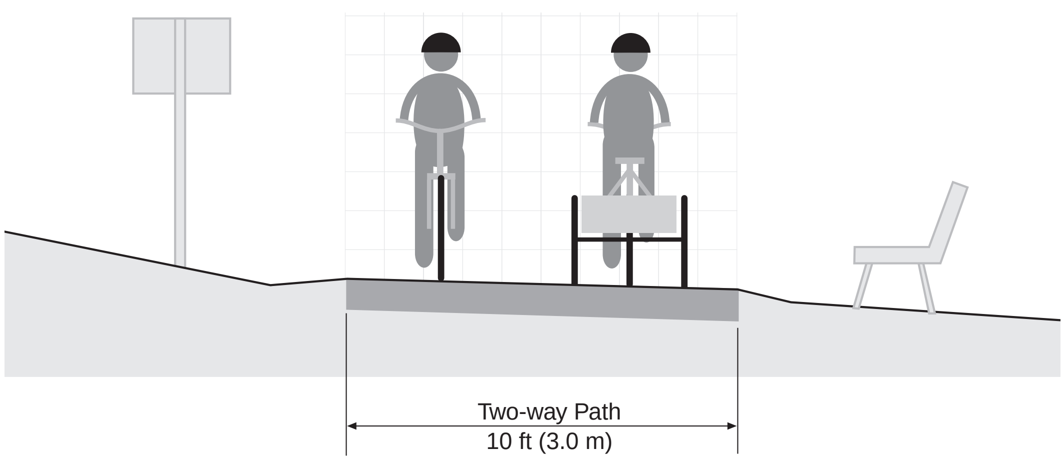
- *proper bicyclist movements through signalized intersections are unclear;*
- *left-turning motorists cross one direction of motor vehicle traffic and two directions of bicycle traffic, increasing conflicts;*
- *bicyclist right turns from the center of the roadway are unnatural for bicyclists and confusing to motorists;*
- *where intersections are infrequent, bicyclists will enter or exit paths at mid-block; and*
- *where medians are landscaped, visual relationships between bicyclists and motorists at intersections are impaired.*

For the above reasons, bikeways in the medians of non-access-controlled roadways should be considered only when the above problems can be avoided. Shared-use paths should only be provided in the medians of freeways or expressways if crossings can be avoided.

4.4. Path width

The paved width required for a shared-use path is a primary design consideration. Figure 4-8 shows a shared-use path on a separate right of way. Under most conditions, the paved width for a two-way shared-use path is 10 ft (3.0 m).

Figure 4-8: The standard width of a shared-use path. In areas with greater potential use, adding extra width may be appropriate.



In rare instances, a reduced width of 8 ft (2.4 m) can be adequate. This reduced width should be used only where:

- *bicycle traffic is expected to be low, even during peak days or peak hours;*
- *only occasional pedestrian use is expected;*
- *good horizontal and vertical alignment will provide safe and frequent passing opportunities;*
- *the path will not be subjected to loading from standard maintenance vehicles that could ravel pavement edges;*
- *the path is very short (e.g., one connecting two cul-de-sac streets); and*
- *the path connects the main path to neighborhood.*

In many cases, there may be enough potential use to warrant increasing path width to 12 ft (3.6 m), or even 14 ft (4.2 m). Paths in popular parks (fig. 4-9), along regional shorelines, or near large population centers and universities can easily generate high levels of mixed use traffic, attracting bicyclists, joggers, skaters and pedestrians. In addition, the sizes of maintenance and emergency vehicles and presence of steep grades should be taken into account (see Section 4.8 for more information about grades and widths).

Figure 4-9: Paths in popular areas may need to be wider than normal to handle the increased traffic. Note: Helmets are recommended for all bicyclists.

The minimum width of a one-directional shared-use path is 6 ft (1.8 m). However, one-way paths will often be used in both directions (fig. 4-10) unless special precautions are taken in trail design and management.

In general, shared-use paths should be designed as two-way facilities.

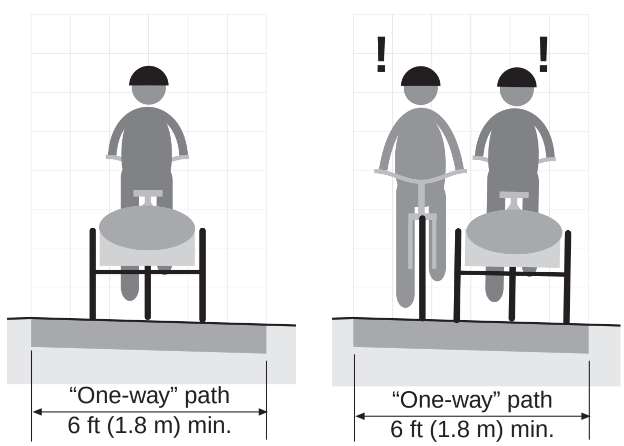


Figure 4-10: One-way paths are often used in two directions unless paired with another nearby one-way path.

Figure 4-11: Maintaining adequate shoulders and proper clearances between the path and obstacles preserves the path's effective width.

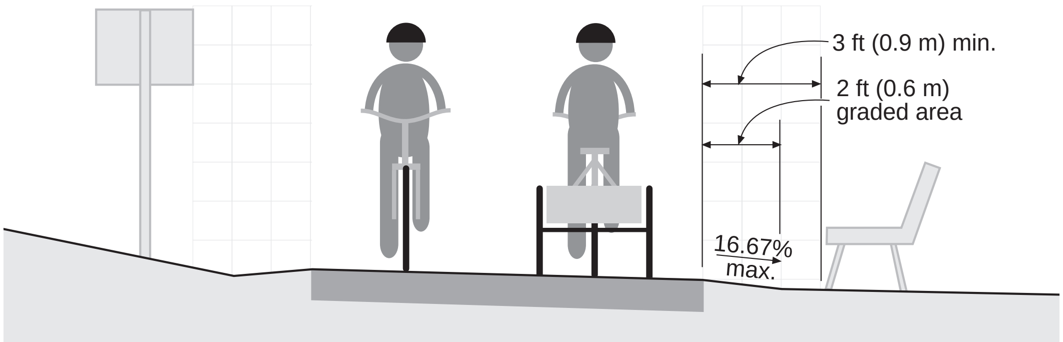


Figure 4-12: Object markings and warning signs should be used where clearances are tight.

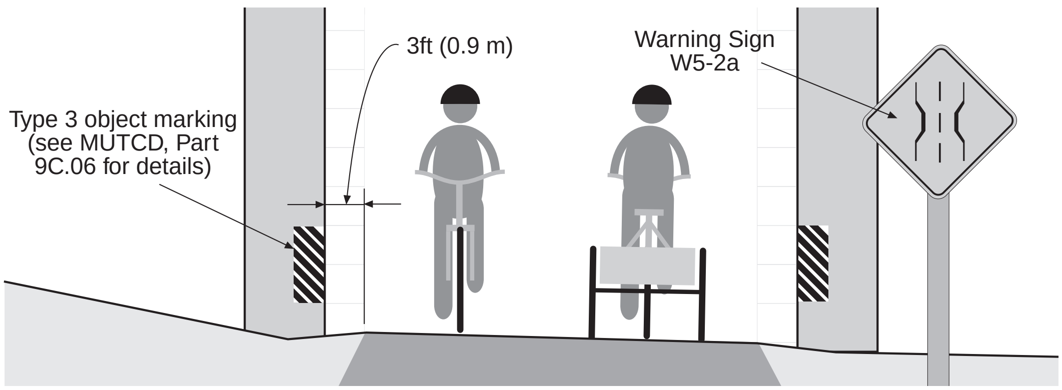


Figure 4-13: Good clearance increases effective path width and makes maintenance less difficult.

4.5 Shoulders and clearances

Shoulders: A minimum 2 ft (0.6 m) wide graded shoulder flatter than 1:6 (16.67%) slope should be maintained on both sides of the path (figs. 4-11, 4-13). Such shoulders provide a measure of safety, in case a bicyclist drifts off the side of the path. The shoulder surface should be level with the edge of pavement, to prevent crashes caused by an uneven pavement edge.

Clearances: In addition, a clear zone of 3 ft (0.9 m) or more is desirable on each side. There are two reasons. The first is to provide adequate clearance from trees, abutments, piers, poles, box culverts, guardrails, or other potential hazards. The second reason is to make maintenance (e.g., mowing) easier.

Such clearances are particularly important for specific individual hazards like trees, box culverts, or posts. But a 1 to 2 ft (0.9 m – 1.8 m) clearance may be used where the obstruction is continuous, as with a long section of wall, a railing, or a fence.

If adequate clearance cannot be maintained between the path and vertical obstructions or other features that narrow the clear zone, a warning sign (fig. 4-12) should be used in advance of the hazard with a Type 1, 2, or 3 object marker at its location (see Part 9C.06 of the MUTCD). This treatment should be used only where the hazard is unavoidable, and is by no means a substitute for good design.

Where the path is next to a canal or ditch, with a sloped drop-off steeper than 3:1 as shown in Figure 4-14, a wider separation should be considered. A minimum 5 ft (1.5 m) separation from the edge of the path pavement to the top of the slope or a safety rail should be provided where the slope/drop conditions in Figure 4-14 cannot be met. Depending on the height of embankment and condition at the bottom, a physical barrier, such as a safety railing, dense shrubbery, or a chain link fence, may be needed at the top of the slope (fig. 4-14.).

The vertical clearance to obstructions (fig. 4-15) should be 10 ft (3 m) for bicyclists' comfort and to allow access for maintenance and emergency vehicles. In special cases, 8 ft (2.5 m) may be used; while uncomfortable for some users, this height allows bicyclists to go under without hitting their heads. The Wisconsin Department of Natural Resources uses a 12-ft (3.6 m) vertical clearance on state trails to accommodate maintenance and snow grooming equipment.

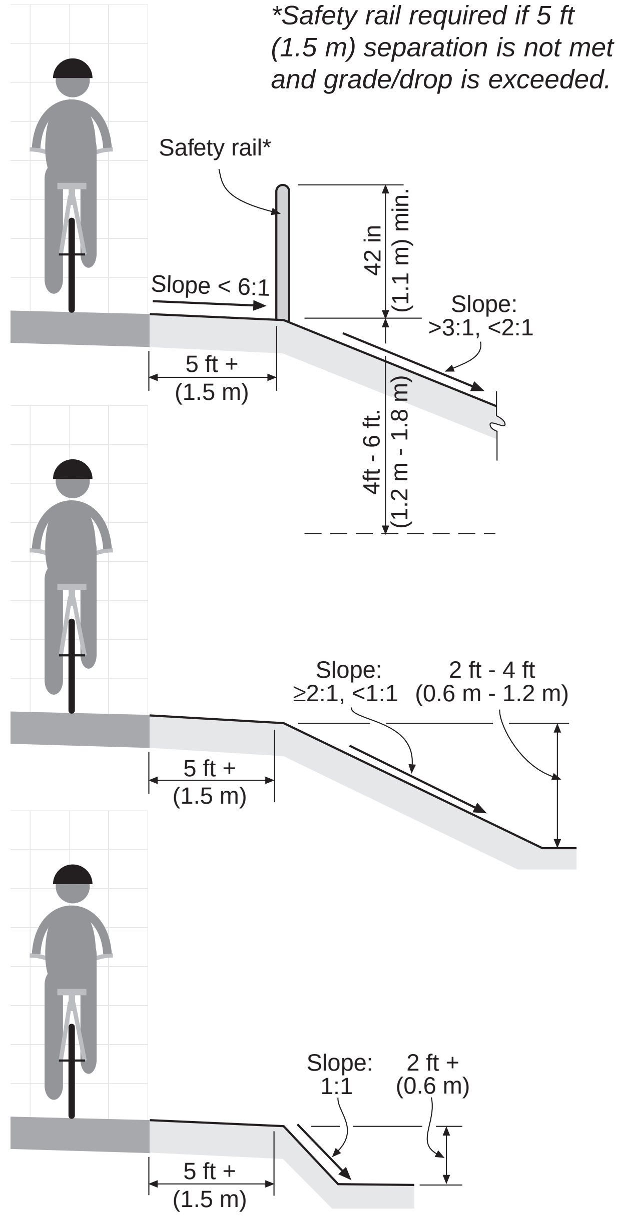


Figure 4-14: Paths next to slopes should be evaluated to determine if mitigation measures are needed.

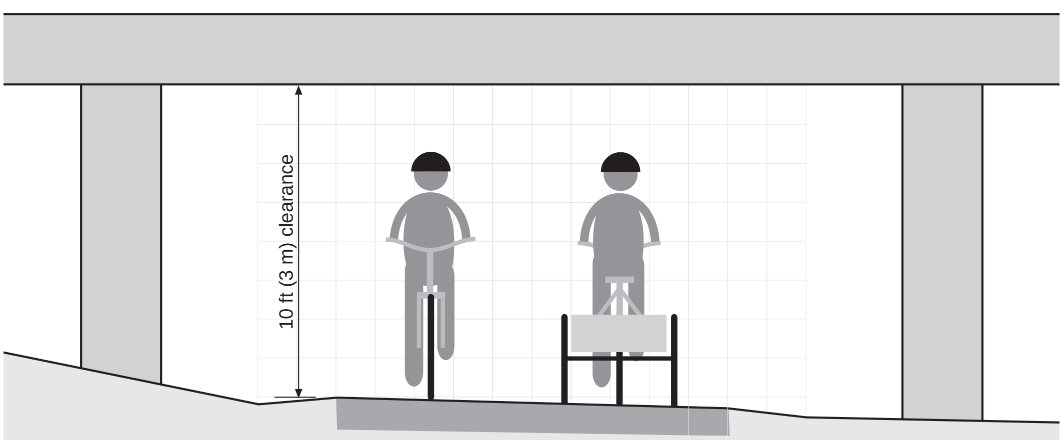


Figure 4-15: Vertical clearance requirements are based, in part, on the need for emergency vehicle access.

Figure 4-16: Using an adequate design speed means better visibility at curves and a reduced potential for unexpected conflicts.

4.6 Design Speed

A bicyclist's speed is dependent on a number of factors, including:

- *type and condition of the bicycle;*
- *trip purpose;*
- *condition, location and grade of the path (fig. 4-17);*
- *speed and direction of any prevailing winds;*
- *number and types of users on the path; and*
- *physical condition of the bicyclist.*

Figure 4-17: Topographical features may require raising the design speed in some cases.

Shared use paths should be designed for a selected speed that is at least as high as the preferred speed of the faster bicyclists. In general, a minimum design speed of 20 mph (30 km/h) should be used.

For paths on long downgrades (i.e., steeper than 4% and longer than 500 ft (150 m)), a design speed of 30 mph (50 km/h) or more is advisable (Section 4.8).

Although bicyclists can travel faster than these speeds, to do so would be inappropriate in a mixed-use setting that includes young bicyclists, pedestrians, wheelchair users, and others. Young bicyclists, for example, may ride at 5 to 10 mph (7 - 15 km/h) and casual adult bicyclists may ride at 10 to 15 mph (15 - 22 km/h). Pedestrians and wheelchair users may travel at 2 to 4 mph (3 - 6 km/h).

Figure 4-18: A green information sign directing faster bicyclists to nearby roadway.

Warning signs can be used to deter excessive bicyclist speed; and faster cyclists can be encouraged to use the roadway system. For example, a "Fast Bicyclist Bypass" can be developed on a nearby through street (fig. 4-18).

On the other hand, lower design speeds should not be selected to attempt to artificially lower user speeds. Lower design speeds should only be considered under special circumstances. For example, terrain constraints may preclude designing to the preferred design speed.

Note: *Installation of "speed bumps" or other similar surface obstructions or staggered gates, intended to slow bicyclists in advance of intersections or other geometric constraints, should not be used. These devices cannot compensate for improper design.*

On unpaved paths (fig. 4-19), where bicyclists tend to ride more slowly, a lower design speed of 15 mph (25 km/h) can be used. Similarly, where the grades or the prevailing winds dictate or if pavement is likely to be added in the future, a higher design speed of 25 mph (40 km/h) can be used. Since bicycles have a higher tendency to skid on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction (see Section 4.7).

Figure 4-19: A popular unpaved shared-use path following an abandoned railroad line.

Figure 4-20: *An example of a trail with gentle curves, good visibility, and clearances.*

Figure 4-21: A bicyclist entering a curve. Note inside pedal is up in preparation for turning.

4.7 Horizontal alignment & superelevation

Background: Unlike an automobile, a bicycle turns by leaning rather than by steering (fig. 4-21). Racing bicyclists use this to their advantage and often turn relatively sharp corners at speed, without losing traction and sliding out.

Casual bicyclists, however, usually prefer not to lean very far, and 15 – 20° is considered the maximum lean angle. In addition, if an unwary bicyclist pedals through a sharp turn and leans too far, the pedal may strike the ground. Although bicycles vary, this generally occurs when the lean angle reaches about 25° and the inside pedal is down (fig. 4-22).

Adult tricycles do not turn by leaning. Like cars and trucks, tricycles turn by steering. As a result, steeply banked paths pull slow-moving tricyclists toward the inside of the curve and can cause the rider to topple over.

Superelevation: Most shared-use paths built in the United States must also meet the requirements of the Americans with Disabilities Act (ADA). ADA guidelines require that cross slopes not exceed 2-3%to avoid the severe difficulties that greater cross slopes can create for wheelchair users.

For most shared-use paths, superelevation should be limited to 2 – 3%. The cross slope helps with drainage and in curves, the path should slope to the inside. When transitioning a 3 % superelevation, a minimum 25 ft (7.5 m) transition distance should be provided between the end and beginning of consecutive and reversing horizontal curves.

Curve radius design: Assuming an operator who sits straight in the saddle, a simple equation can determine the minimum radius of curvature for any given lean angle:

For English Units:

$$R = \frac{0.067\,V^2}{\tan \text{Ø}}$$

Where:
R = Minimum radius of curvature (ft)
V = Design Speed (mph)
Ø = Lean angle from vertical (degrees)

For Metric Units:

$$R = \frac{0.0079\,V^2}{\tan \text{Ø}}$$

Where:
R = Minimum radius of curvature (m)
V = Design Speed (km/h)
Ø = Lean angle from vertical (degrees)

As the lean angle approaches 20°, the minimum radius of curvature negotiable by a bicycle becomes a function of the path's superelevation, the coefficient of friction between the bicycle tires and the surface, and the speed of the bicycle. For this situation, the minimum design radius of curvature can be derived from the following formula:

For English Units:

$$R = \frac{V^2}{15\left(\frac{e}{100} + f\right)}$$

Where:
R = Minimum radius of curvature (ft)
V = Design Speed (mph)
e = Rate of superelevation (percent)
f = Coefficient of friction

For Metric Units:

$$R = \frac{V^2}{127\left(\frac{e}{100} + f\right)}$$

Where:
R = Minimum radius of curvature (m)
V = Design Speed (km/h)
e = Rate of superelevation (percent)
f = Coefficient of friction

The coefficient of friction (f) depends upon speed; surface type, roughness, and condition; tire type and condition; and whether the surface is wet or dry. Friction factors used for design should be selected based

Figure 4-22: Bicycles turn by leaning. Too much lean can cause a "pedal strike." Tricycles turn by steering.

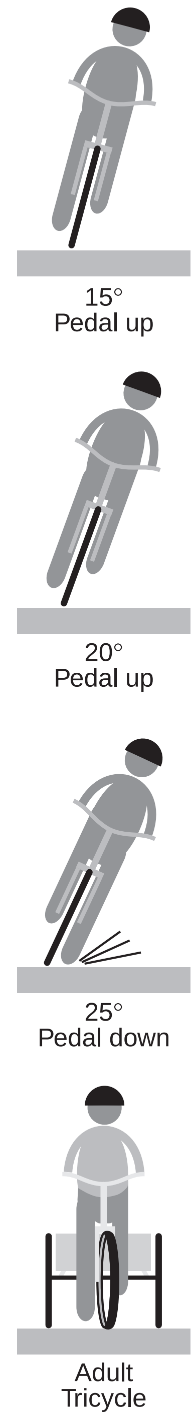
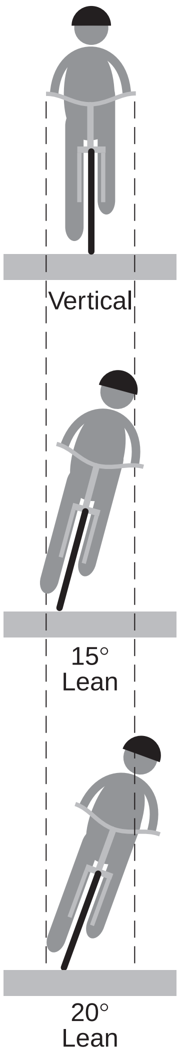


Figure 4-23 (below): A bicyclist has a greater effective width while leaning in a curve.



upon the point at which centrifugal force causes the bicyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed.

Extrapolating from values used in highway design, friction factors for paved shared-use paths can be assumed to vary from 0.31 at 12 mph (20 km/h) to 0.21 at 30 mph (50 km/h). Although there are no data available for unpaved surfaces, reducing friction factors by 50% should allow a sufficient margin of safety.

Note: The formulas on page 4-15 are given for reference purposes. However the maximum desirable lean angle for a shared-use path is 15°.

Based upon design speeds of 20 to 30 mph (30-50 km/h) and a desirable maximum lean angle of 15°, minimum radii of curvature for a paved path can be selected from Table 4-1. While the radii shown are not based on any superelevation, a 2% cross slope to the inside of the curve is recommended for drainage purposes. Note that a design speed of 12 mph (18 km/h) may be used in special situations (e.g., where physical constraints dictate a lower design speed and tighter curve). For crushed stone paths, the minimum radius at the minimum design speed (15mph) is approximately 90 ft due to a much lower friction factor.

Table 4-1: Desirable Minimum Radii for Paved Shared Use Paths

Based on 15° Lean Angle

Design Speed (V)		*Minimum Radius (R)*	
mph	*(km/h)*	*ft*	*(m)*
20	(30)	100	(27)
25	(40)	156	(47)
30	(50)	225	(74)
Special conditions (e.g., topography constraints):			
12	(20)	36	(12)
15	(25)	56	(18)

(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

Figure 4-24: A gentle curve combined with good sight distance.

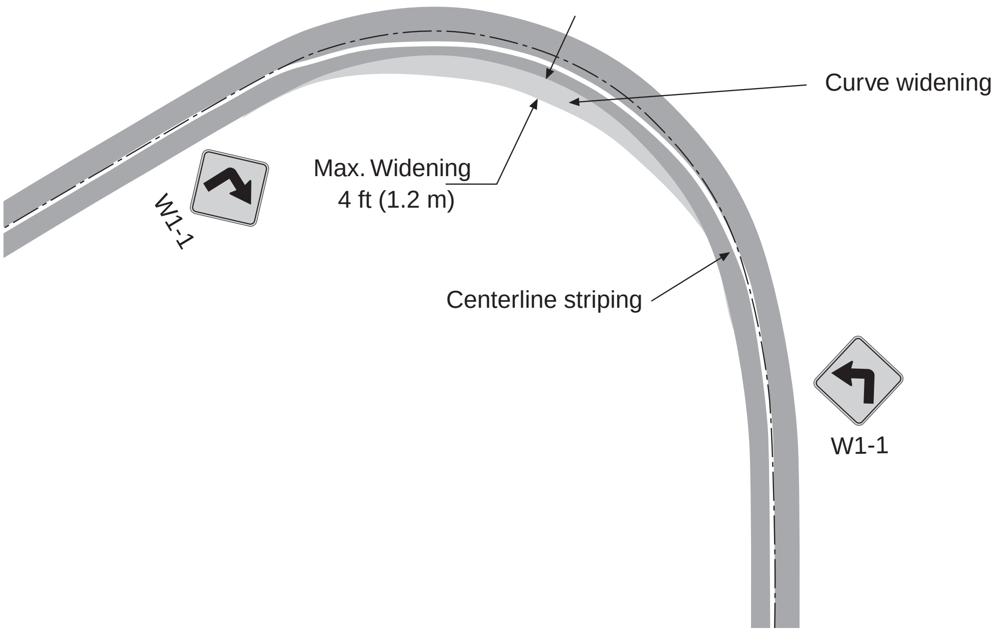


Figure 4-25: In tight curves, a centerline stripe can help keep bicyclists on the proper side. "Curve Ahead" (W1-1) warning signs and curve widening also help improve the curve's safety.

Figure: 4-26: An example of centerline striping used in a curve to separate bicyclists going opposite directions. In this case, no curve widening was used, however vegetation has been trimmed back to improve sight lines.

In cases where substandard curve radii are unavoidable, curve warning signs, centerline striping (fig. 4-26), and curve widening should be used (fig. 4-25). Curve widening means increasing the width of the path through the curve and, as a result, modifying the radius. Typically, a center line is placed down the middle of the path and W1-1 warning signs may be used (fig. 4-25)

Figure 4-27: Shared-use paths should be designed for all ages. Grades should be carefully considered and should be safe for kids riding coaster brake bicycles.

4.8 Grades

Shared-use paths generally attract less-skilled bicyclists, so it is important to avoid steep grades, to the extent possible (Table 4-2). Many bicyclists will find themselves walking on long, steep uphill grades. On downhills, bicyclists may exceed the speed at which they can safely control their bicycles. As a result, paths with long, steep grades are difficult for many bicyclists.

The maximum grade rate recommended for shared-use paths is 5%. Sustained grades should be limited to 2 or 3% if a wide range of riders is to be accommodated. The AASHTO *Guide for the Development of Bicycle Facilities* acknowledges that on recreational routes, designers may need to exceed a 5% grade for short sections.

As a general guide, where steeper or longer grades cannot be avoided, the design speed should be increased and additional width should be provided for maneuverability. Grades in excess of 8.3% (12:1) exceed the standard set in the ADA Accessibility Guidelines for pedestrian facilities and should only be used if the path is likely to see little pedestrian use.

Table 4-2. Suggested Grade Limits for Paved Shared Use Paths

Grade	*Maximum Recommended Length*	
Percent	*ft*	*(m)*
5-6	800	(240)
7	400	(120)
8	300	(90)
9	200	(60)
10	100	(30)
≥11	50	(15)

Note: Min. design speed for grades = 30mph (50km/h).

(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

Options to mitigate excessive grades:

- *on longer grades, widen path 4 to 6 ft (1.2 - 1.8 m) so slower speed bicyclists can dismount and walk;*
- *Use warning signs at the top to alert bicyclists to the grade (fig. 4-28), with subplates with recommended descent speed;*
- *Increase stopping sight distances for the downhill direction;*
- *Increase horizontal clearances, add a recovery area, and/or add protective railings;*
- *Widen path and add a series of short switchbacks to slow descending bicyclists (switchbacks should be near – or start at – the top of the hill, rather than at the bottom where speeds are likely to be greater).*

W7-5

Figure 4-28: A warning sign for use in advance of steep path grades.

Unpaved paths: Grades steeper than 3% may not be practical for shared-use paths with crushed stone or other unpaved surfaces for both handling and drainage erosion reasons. Note: recreational mountain bike trails may include steeper grades (see the Bibliography for references).

4.9 Transitions between grades and level ground

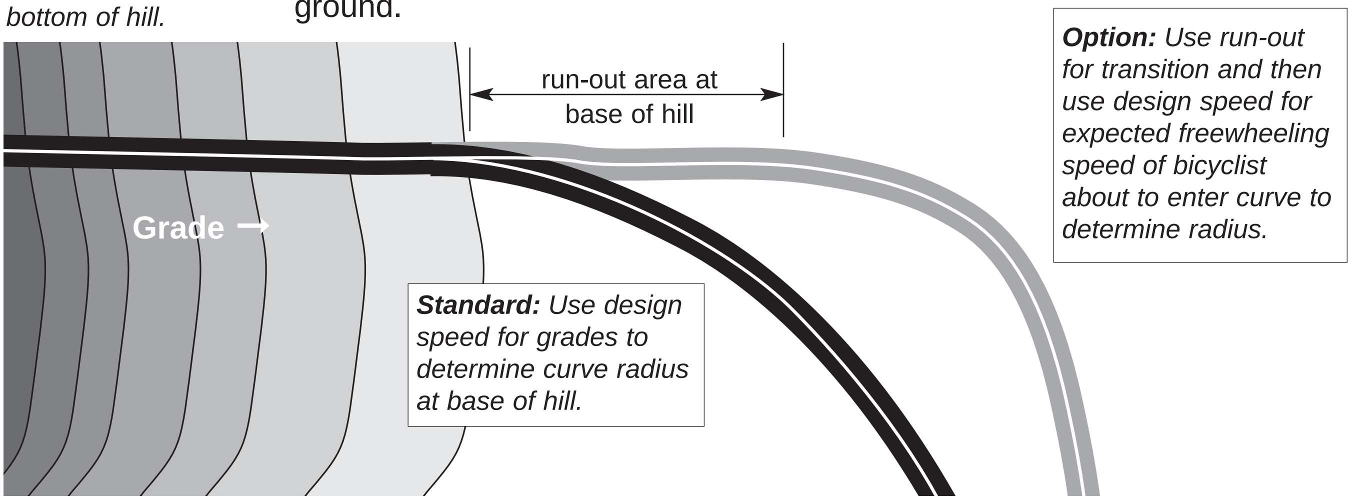
While a 30 mph (50 km/h) design speed is suggested for grades, the design speed for level ground is 20 mph (30 km/h). Yet, it would be an error to use 20 mph as the design speed in determining the radius or the sight distance required for a curve at the bottom of a grade. Descending bicyclists will likely still be going faster for some way after they reach level ground. Similarly, stopping sight distance for an intersection at the bottom of a hill should reflect the higher speeds of entering bicyclists.

If the curve or intersection must be located at the bottom of a grade, the proper approach is to use 30 mph (50 km/h) as the design speed in determining curve radius or stopping sight distance.

Figure 4-29: Bicyclists often enjoy going downhill; it's important to remember this while designing shared-use paths.

The run-out distance is a factor of the minimum stopping sight distance and minimum curve radii requirements of the curve that the bicyclist is about to enter at the end of the run-out (fig. 4-30). The bicyclist's anticipated "freewheeling speed" should be used for curve design. In unique circumstances where topographic and site characteristics limit the potential run-out length, the minimum run-out may be computed as the difference between the stopping sight distance for the grade and that for level ground.

Figure 4-30: Options for handling a curve at the bottom of hill.



Where the minimum run-out is used, appropriate warning signage needs to be posted to warn cyclists that they need to begin slowing (within the run-out area) so they can safely negotiate an upcoming curve designed for a slower speed than they are currently traveling. For example, at 30 mph (50 km/h), the stopping sight distance is 225 ft (74m) and at 20 mph (30 km/h), the stopping sight distance is 125 ft (38m). The difference of 100 feet (30 m) would be the minimum run-out distance required to allow bicyclists to slow to the level grade design speed of 20 mph (30 km/h).

Applying a run-out is also beneficial for paths leading to a stop or yield sign, although there is no formula to compute the minimum run-out. The minimum stopping sight distance would have to be met under these conditions.

Figure 4-31: Overhanging bushes on the inside of this curve reduce sight distance and narrow the path.

4-10 Sight Distance

Shared-use paths should be designed with adequate stopping sight distances to let bicyclists see and react to the unexpected situations (fig. 4-31). The distance required to bring a bicycle to a full controlled stop is a function of the bicyclist's perception and brake reaction time; the initial bicycle speed; the coefficient of friction between the tires and pavement; and the braking ability of the bicycle and the bicyclist.

Figure 4-32 and 4-34 (below and on next page) indicate the minimum stopping sight distance for various design speeds and grades. These distances are based on a combined perception and brake reaction time of 2.5 seconds and a coefficient of friction of 0.25 to account for the poor wet weather braking characteristics of many bicycles. For two-way shared use paths, the sight distance in the descending direction, that is, where "G" is negative, will control the design.

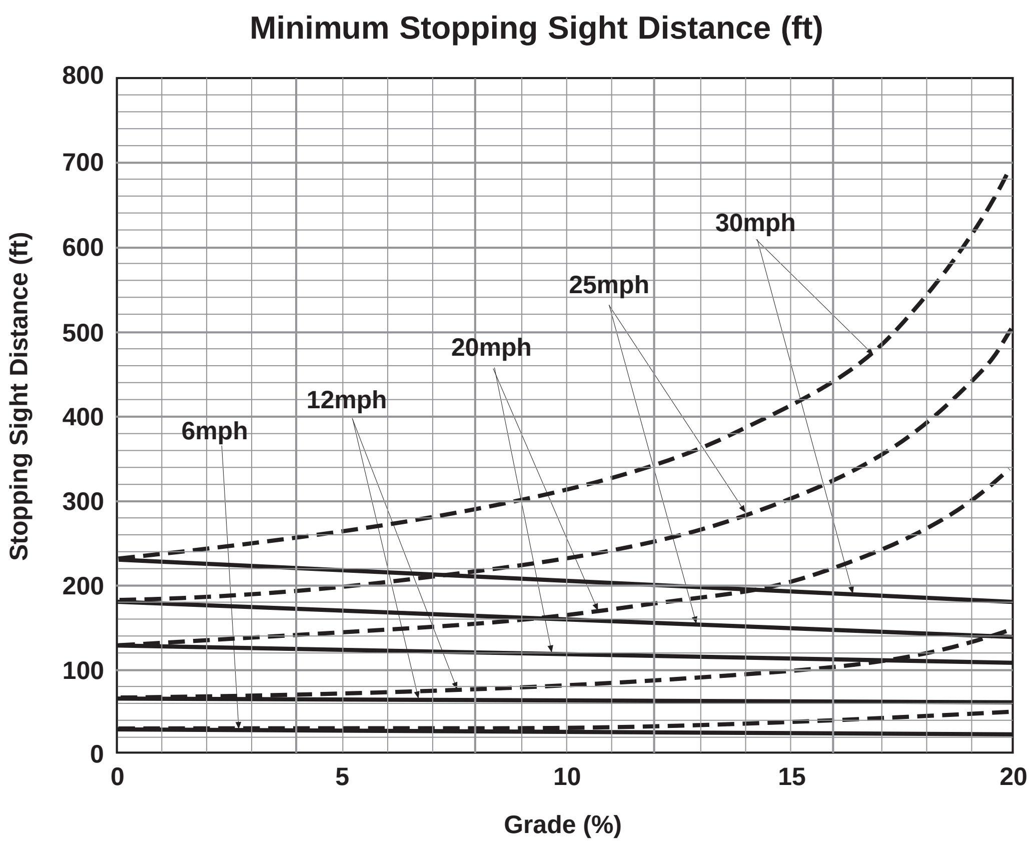


Figure 4-32: Minimum stopping sight distance is determined based on design speed and grade. (English units)
(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

$$S = \frac{V^2}{30(f \pm G)} + 3.67V$$

Descend - - - -
Ascend ——

Where:

S = Stopping sight distance (ft)
V = Velocity (mph)
f = Coefficient of friction (use 0.25)
G= Grade (ft/ft) (rise/run)

Example: Determine the Descending Stopping Sight Distance for a 4% grade. Assume a 30 mph speed and follow the dashed 30 mph line to where it intersects the vertical line for 4% (fig. 4-33). The result is 250 ft.

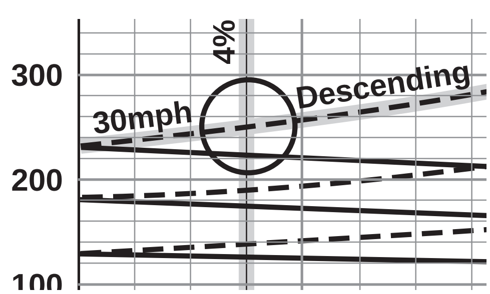


Figure 4-33: A close-up view of the graph in fig. 4-29, showing the intersection of the 30mph downhill line and the 4% grade line.

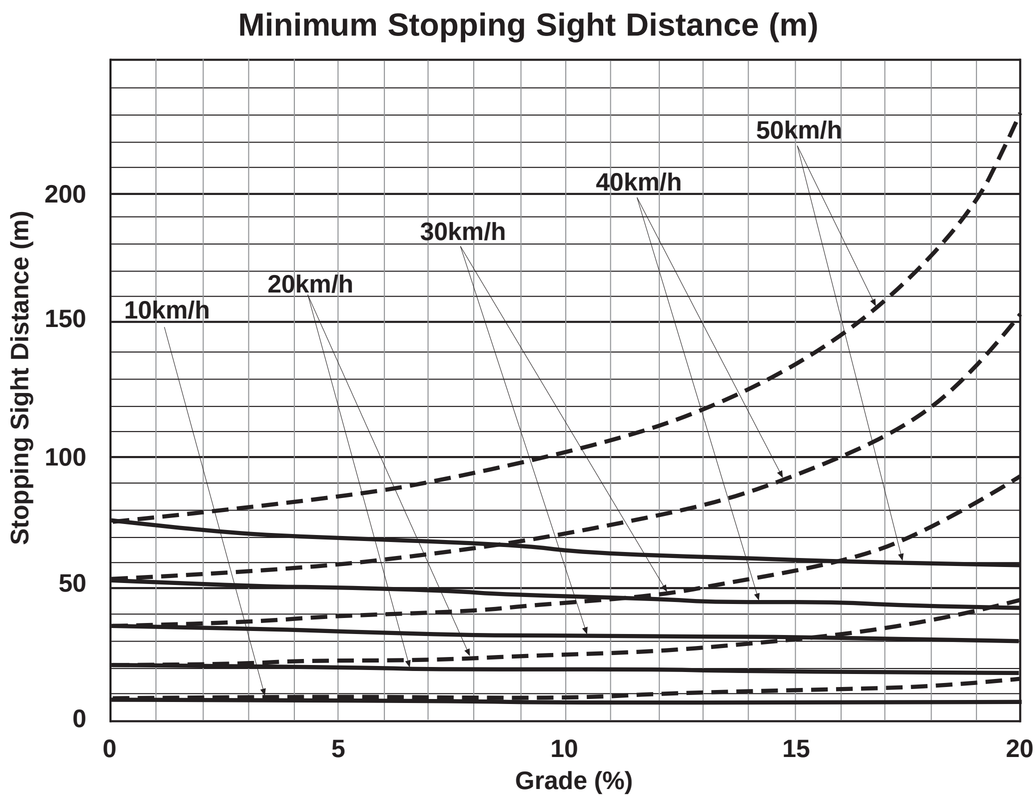


Figure 4-34: Minimum stopping sight distance is determined based on design speed and grade. (Metric units)
(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

$$S = \frac{V^2}{254(f \pm G)} + \frac{V^2}{1.4}$$

Descend - - - -
Ascend ———

Where:
S = Stopping sight distance (m)
V = Velocity (km/h)
f = Coefficient of friction (use 0.25)
G= Grade (m/m) (rise/run)

Vertical curves: Tables 4-3 (English units) and 4-4 (Metric units) are used to select the minimum length of vertical curve necessary to provide sufficient stopping sight distance at various speeds on crest vertical curves. The bicyclist's eye is assumed to be 4.5 ft (1.4 m) above the pavement. The object height is assumed to be 0 ft. (0 m) since obstacles are often found at pavement level. Use these two tables; however, an additional table showing *K factors*** is planned for the appendix of this guide.

Horizontal curves: The minimum lateral clearance for sight obstructions on horizontal curves is illustrated in figure 4-35. Tables 4-5 (English units) and 4-6 (Metric units) give those values, based on a selected curve radius and the stopping sight distance (taken from figures 4-32 (English) or 4-34 (Metric). Bicyclists often ride side-by-side on shared-use paths. On paths they may ride near the center. This is also true if vegetation or other path-side obstructions encroach on the effective path width.

*** **K factors**: relationship of speed to vertical curve lengths and grades*

(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

Table 4-3: Minimum Length (in feet) of Crest Vertical Curve (L)

A	Based on Stopping Sight Distance														
	S = Stopping Sight Distance (ft)														
(%)	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6				10	50	90	130	171	216	267	323	384	451	523	600
7				31	71	111	152	199	252	311	376	448	526	610	700
8			8	48	88	128	174	228	288	356	430	512	601	697	800
9			20	60	100	144	196	256	324	400	484	576	676	784	900
10			30	70	111	160	218	284	360	444	538	640	751	871	1000
11			38	78	122	176	240	313	396	489	592	704	826	958	1100
12		5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13		11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14		16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15		20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16		24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17		27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18		30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19		33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20		35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21		37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22		39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23		41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	3	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	4	44	100	177	278	400	544	711	900	1111	1344	1600	1878	2178	2500

when $S > L$ $L = 2S - \frac{900}{A}$

when $S < L$ $L = \frac{AS^2}{900}$

Shaded area represents S = L

L = Min. length of vertical curve (ft)
A = Algebraic grade difference (%)
S = Stopping sight distance (ft)

Height of cyclist eye = 4.5 ft
Height of object = 0 ft
Min. length of vertical curve = 3 ft

NOTE: *For these reasons, and because of the higher potential for bicycle crashes, lateral clearances on horizontal curves should be calculated based on* ***the sum of the stopping sight distances*** *for bicyclists traveling in opposite directions around the curve.*

Where adequate sight distance cannot be provided, mitigation measures like those described below can help:

- *widen the path through the curve (see fig. 4-25);*
- *Install a solid yellow center line stripe (fig. 4-26);*
- *Install a "Curve Ahead" warning sign (fig. 4-25); or*
- *Some combination of the above.*

(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

Table 4-4: Minimum Length (in meters) of Crest Vertical Curve (L)

Based on Stopping Sight Distance

A (%)	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
	S = Stopping Sight Distance (m)																		
2														10	20	30	40	50	60
3									7	17	27	37	47	57	67	77	87	97	107
4							10	20	30	40	50	60	70	80	91	103	116	129	143
5					4	14	24	34	44	54	64	75	88	100	114	129	145	161	179
6				3	13	23	33	43	54	65	77	91	105	121	137	155	174	193	214
7				10	20	30	40	51	63	76	90	106	123	141	160	181	203	226	250
8			5	15	25	35	46	58	71	86	103	121	140	161	183	206	231	258	286
9			9	19	29	39	51	65	80	97	116	136	158	181	206	232	260	290	321
10		2	12	22	32	44	57	72	89	108	129	151	175	201	229	258	289	322	357
11		5	15	25	35	48	63	80	98	119	141	166	193	221	251	284	318	355	393
12		7	17	27	39	53	69	87	107	130	154	181	210	241	274	310	347	387	429
13		8	18	29	42	57	74	94	116	140	167	196	228	261	297	335	376	419	464
14		10	20	31	45	61	80	101	125	151	180	211	245	281	320	361	405	451	500
15	1	11	21	33	48	66	86	108	134	162	193	226	263	301	343	387	434	483	536
16	3	13	23	36	51	70	91	116	143	173	206	241	280	321	366	413	463	516	571
17	4	14	24	38	55	74	97	123	152	184	219	257	298	342	389	439	492	548	607
18	4	14	26	40	58	79	103	130	161	194	231	272	315	362	411	464	521	580	643
19	5	15	27	42	61	83	109	137	170	205	244	287	333	382	434	490	550	612	679
20	6	16	29	45	64	88	114	145	179	216	257	302	350	402	457	516	579	645	714
21	7	17	30	47	68	92	120	152	188	227	270	317	368	422	480	542	608	677	750
22	7	18	31	49	71	96	126	159	196	238	283	281	385	442	503	568	636	709	786
23	8	18	33	51	74	101	131	166	205	248	296	347	403	462	526	593	665	741	821
24	8	19	34	54	77	105	137	174	214	259	309	362	420	482	549	619	694	774	857
25	9	20	36	56	80	109	143	181	223	270	321	377	438	502	571	645	723	806	893

when S > L $L = 2S - \frac{280}{A}$

Shaded area represents S = L

when S < L $L = \frac{AS^2}{280}$

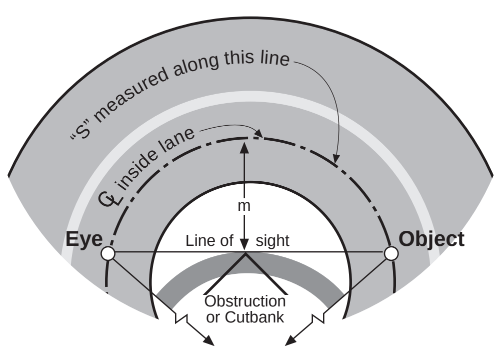
L = Min. length of vertical curve (m)
A = Algebraic grade difference (%)
S = Stopping sight distance (m)

Height of cyclist eye - 1.4 m
Height of object - 0 m

Min. length of vertical curve = 1 m

Figure 4-35: Minimum Lateral Clearance (M) for Horizontal Curves (after AASHTO Guide for the Development of Bicycle Facilities, 1999)

Minimum Lateral Clearance (M) for Horizontal Curves



Line of sight - 700 m above centerline of inside lane at point of obstruction

$$M = R\left[1 - \cos\left(\frac{28.65S}{R}\right)\right]$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-M}{R}\right)\right]$$

S = Stopping sight distance (m or ft)
R = Radius of centerline of lane (m or ft)
M = Dist. from centerline of lane to obstruction
Angle expressed in degrees
Formula applies when S ≤ length of curve

Table 4-5: Minimum Lateral Clearance (M) for Horizontal Curves*

(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

(English Units)															
R(ft)	S = Stopping Sight Distance (ft)														
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	
25	2.0	7.6	15.9												
50	1.0	3.9	8.7	15.2	23.0	31.9	41.5								
75	0.7	2.7	5.9	10.4	16.1	22.8	30.4	38.8	47.8	57.4	67.2				
95	0.5	2.1	4.7	8.3	12.9	18.3	24.7	31.8	39.5	48.0	56.9	66.3	75.9	85.8	
125	0.4	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.6	79.7
155	0.3	1.3	2.9	5.1	8.0	11.5	15.5	20.2	25.4	31.2	37.4	44.2	51.4	59.1	67.1
175	0.3	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.5	39.6	46.1	53.1	60.5
200	0.3	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.2	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.3	36.5	42.2	48.2
250	0.2	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.1	38.2	43.7
275	0.2	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.2	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.1	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
390	0.1	0.5	1.2	2.1	3.2	4.6	6.3	8.2	10.3	12.8	15.4	18.3	21.5	24.9	28.5
500	0.1	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
565		0.4	0.8	1.4	2.2	3.2	4.3	5.7	7.2	8.8	10.7	12.7	14.9	17.3	19.8
600		0.3	0.8	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700		0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800		0.3	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900		0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.6	6.7	8.0	9.4	10.9	12.5
1000		0.2	0.5	0.8	1.3	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2

Table 4-6: Minimum Lateral Clearance (M) for Horizontal Curves*

(after AASHTO Guide for the Development of Bicycle Facilities, 1999)

(Metric Units)																			
R(m)	S = Stopping Sight Distance (m)																		
10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
10	1.2	2.7	4.6	6.8	9.3														
15	0.8	1.8	3.2	4.9	6.9	9.1	11	14											
20	0.6	1.4	2.4	3.8	5.4	7.2	9.2	11	14	16	19								
25	0.5	1.1	2	3.1	4.4	5.9	7.6	9.5	11	14	16	18	21	23					
50	0.3	0.6	1	1.6	2.2	3	3.9	5	6.1	7.4	8.7	10	12	13	15	17	19	21	23
75	0.2	0.4	0.7	1	1.5	2	2.7	3.4	4.1	5	5.9	6.9	8	9.2	10	12	13	15	16
100	0.1	0.3	0.5	0.8	1.1	1.5	2	2.5	3.1	3.8	4.5	5.2	6.1	7	7.9	8.9	10	11	12
125	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2	2.5	3	3.6	4.2	4.9	5.6	6.3	7.2	8	8.9	9.9
150		0.2	0.3	0.5	0.7	1	1.3	1.7	2.1	2.5	3	3.5	4.1	4.7	5.3	6	6.7	7.5	8.3
175		0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.8	2.2	2.6	3	3.5	4	4.6	5.1	5.8	6.4	7.1
200		0.1	0.3	0.4	0.6	0.8	1	1.3	1.6	1.9	2.2	2.6	3.1	3.5	4	4.5	5	5.6	6.2
225		0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.7	2	2.3	2.7	3.1	3.5	4	4.5	5	5.5
250		0.1	0.2	0.3	0.5	0.6	0.8	1	1.2	1.5	1.8	2.1	2.4	2.8	3.2	3.6	4	4.5	5
275		0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.4	1.6	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.5
300			0.2	0.3	0.4	0.5	0.7	0.8	1	1.3	1.5	1.8	2	2.3	2.7	3	3.4	3.8	4.2

** Minimum lateral clearance should be measured from the centerline of the inside lane, as per Figure 4-35.*
FDM 11-10-5 (figure 6) presents comparable data in a graph by various design speeds and stopping sight distances for roadway design purposes. A similar graph is planned for the appendix of this guide.

Figure 4-36: A smooth path surface is one element required for a safe bicycle ride.

4.11 Pavement structure

Designing and selecting pavement sections for shared use paths is in many ways similar to designing and selecting highway pavement sections. A soils investigation should be conducted to determine the load-carrying capabilities of the native soil, unimproved shoulder, or former railroad bed (if ballast has been removed), and the need for any special provisions. Table 4-7 shows some surface types, as well as their advantages and disadvantages.

Hard pavement surfaces are usually preferred over those of crushed aggregate, sand, clay or stabilized earth since these materials provide a lower quality of service and may require greater maintenance. In addition, such “soft” surfaces do not work well on paths intended for all-weather — and all-season — transportation use (e.g., commuting).

Rutting or other damage may occur on such paths that see heavy use in wet weather or during the spring thaw. Also, in areas subjected to flooding or drainage problems, or in areas of steep terrain, unpaved surfaces will often erode and are not recommended. Further, wheelchair users are not well-served by unpaved paths. Paths in or near communities, in particular, should be considered for paving, either with asphalt or concrete.

On the other hand, many of Wisconsin’s more recreation-oriented paths, particularly in rural areas, are surfaced with crushed aggregate (limestone and rotten granite). These path surfaces can reduce bicyclists’

Table 4-7: Path Surface Summary

Surface Material	*Advantages*	*Disadvantages*
Soil cement	Uses natural materials, more durable than native soils, smoother surface, low cost.	Surface wears unevenly, not a stable all-weather surface, erodes, difficult to achieve correct mix.
Crushed aggregate	Soft but firm surface, natural material, moderate cost (varies regionally), smooth surface, accommodates multiple use.	Surface can rut or erode with heavy rainfall, regular maintenance to keep consistent surface, replenishing stones may be a long-term expense, not for steep slopes.
Asphalt	Hard surface, supports most types of use, all weather, does not erode, accommodates most users simultaneously, low maintenance.	High installation cost, costly to repair, not a natural surface, freeze/thaw can crack surface, heavy construction vehicles need access.
Concrete	Hardest surface, easy to form to site conditions, supports multiple use, lowest maintenance, resists freeze/thaw, best cold weather surface.	High installation cost, joints must be sawn for smooth ride, costly to repair, not natural looking, construction vehicles will need access to the trail corridor.
Native soil	Natural material, lowest cost, low maintenance, can be altered for future improvements, easiest for volunteers to build and maintain.	Dusty, ruts when wet, not an all-weather surface, can be uneven and bumpy, limited use, inappropriate for bicycles and wheelchairs.
Recycled materials	Good use of recyclable materials, surface can vary depending on materials.	High purchase and installation cost, life expectancy unknown.

speeds. And, they have typically been built in less time and at lower cost than paths built with asphalt or concrete. However, the surface of choice in one part of the state may be expensive elsewhere. For example, limestone topped off with screenings is expensive in central and western Wisconsin. There, some agencies use rotten disintegrated granite while others have used seal coat treatments (e.g., Chippewa River Trail, Omaha Trail). Whichever material is available in a particular part of the state, it is fair to say that crushed aggregate is the preferred surface type for the majority of Wisconsin's many "rail-trails."

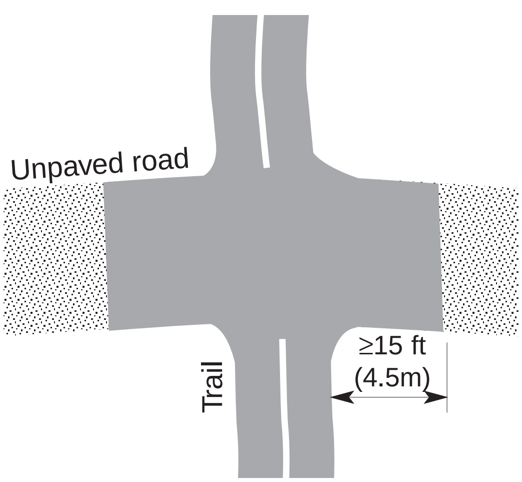
Figure 4-37: Pavement loads must take into account maintenance and emergency vehicles.

4.11.1 Pavement loads

While loads on shared use paths will be substantially less than those used in highway design, paths should hold up under the weight of occasional emergency, patrol, maintenance and other motor vehicles expected to use or cross the path (fig. 4-37). The pavement structure at highway or driveway crossings, in particular, should be adequate to sustain the expected loading at those locations.

Figure 4-38: Paving into unpaved roads or driveways that cross the path can help keep gravel off the path's surface.

When motor vehicles are driven on shared-use paths, their wheels will often be very near the edges of the path. They may occasionally go off the pavement and then come back on. This can cause the path edge to ravel, which, in turn, will reduce the path's effective width. For this reason, adequate edge support should always be provided. Building to the standard 10 ft (3.0 m) width can also help lessen the edge raveling and shoulder rutting problems, since motor vehicles will have an easier time staying on the path. Providing gravel shoulders, as recommended earlier, can also help, as can widening the path to 12 ft (3.6 m) or greater.



Where shared-use paths cross unpaved highways or driveways, the highway or driveway should be paved a minimum of 15 ft (4.5 m) on each side of the crossing to reduce the amount of gravel being scattered along the path by motor vehicles (fig. 4-38). Where the roadway descends a grade to the crossing, paving should be extended farther.

4.11.2 Vegetation Control

Vegetation control is generally considered the responsibility of a path's maintenance forces. However, to provide longer path life and lower maintenance costs, it should also be considered during design and construction (fig. 4-39).

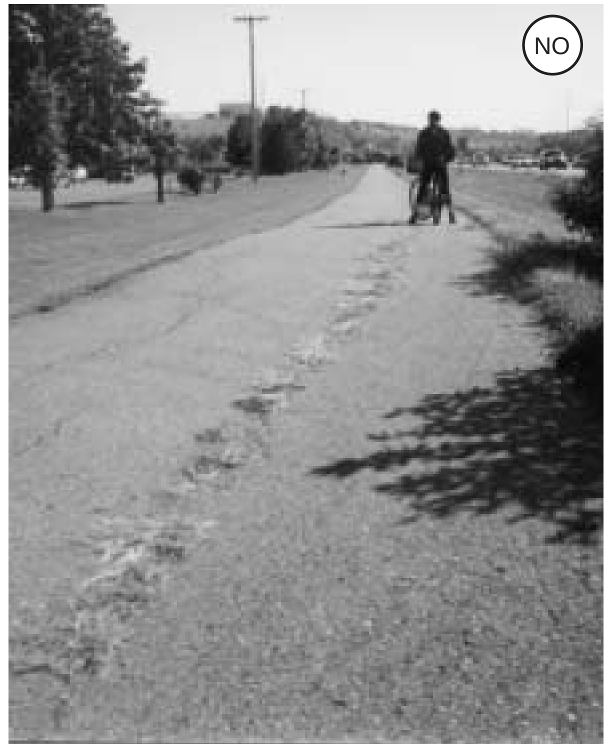


Fig. 4-39: Weeds break through a relatively new path.

The following are examples of vegetation control methods that may be useful during design and construction:

1. Place a non-selective herbicide under the path. All applications must be done according to label directions. The applicator must be licensed by the Wisconsin Department of Agriculture. It is common for thin bituminous surfaces with shallow subsurface treatments, such as walking trails, to be ruined by vegetation. This herbicide will prevent vegetation from penetrating the asphalt for a number of years. However, non-selective herbicides may injure nearby trees if their root systems grow into the treated area.

2. Place a tightly woven geotextile or landscape fabric between the subgrade and base course. This method may be used in sensitive areas where a non-selective herbicide is undesirable. It is also useful in areas with questionable soil conditions (e.g., a marsh or other wet area). Several brands of geotextiles provide additional structural support for the paving as well.

3. Require selective vegetation removal or path realignment. Trees or shrubs may encroach into the path's clear zone (fig. 4-40), reducing the path's effective width and stopping sight distance — and possibly causing bicycle crashes. Removing trees or shrubs that encroach or changing the path alignment can eliminate the problem.

Fig. 4-40: Poor alignment reduces the effective width of this path.

4.11.3 Foundation preparation

Soil support and drainage conditions should be carefully evaluated prior to designing the pavement structure. This evaluation will identify areas needing special site corrections, such as unstable or unsuitable soil conditions that can be located and treated.

Figure 4-41: Preparing shared-use path subgrade.

Establishing a suitable foundation is essential to the success and longevity of the path. The following tasks should be included:

- *remove all unsuitable vegetation, topsoil, and other soils to the path's edge.* If trees are removed, all surface roots should be removed;
- *provide subgrade preparation to shape and compact the subgrade.* Provide subcut compaction and corrections as determined by the engineer;
- *place geotextile fabric on unstable soils if the engineer determines its use is appropriate.* The fabric should separate the aggregate base from unstable soils or sand; and
- *stabilize granular subgrades, if necessary.* Incorporate stabilizing aggregate into the upper portion of the subgrade to achieve adequate surface stability.

Figure 4-42: Machine-laid asphalt is smooth and a common surface for shared-use paths.

4.11.4 Asphalt structural section

Aggregate-based asphalt surfacing is generally recommended for paths (fig. 4-43). Full-depth bituminous may be considered where subgrade soils are relatively granular. It may be necessary to increase the pavement thickness where numerous heavy vehicles use or cross the path (at driveways, etc).

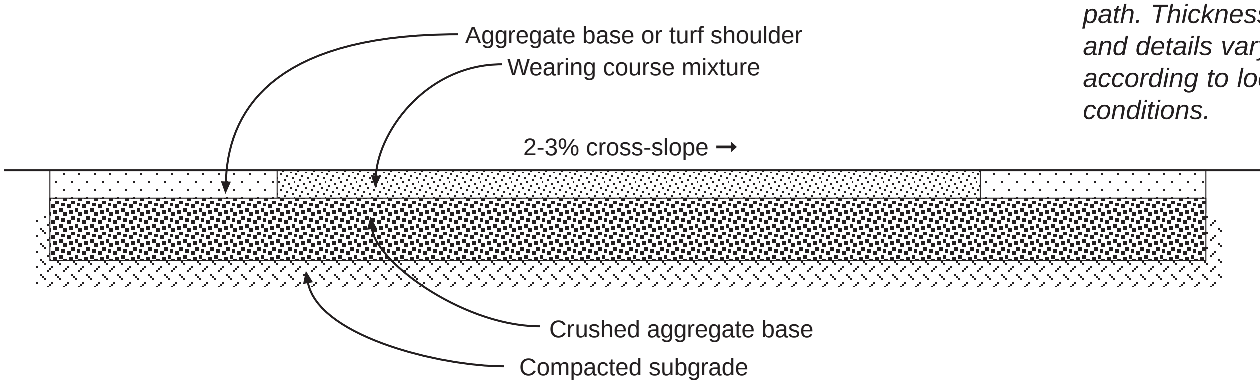


Figure 4-43: Cross section of asphalt path. Thickness and details vary according to local conditions.

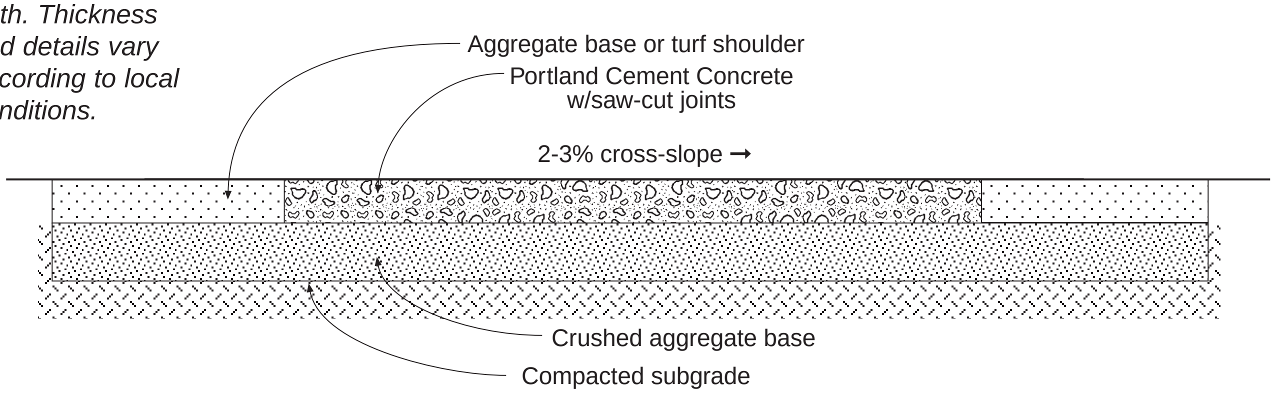
Aggregate base should be increased in heavy soils where maintenance and emergency vehicles may cause pavement damage. Aggregate base thickness may be reduced for granular subgrade soils.

Figure 4-44: Concrete can provide a smooth and long-lived surface, as shown on this shared-use path.

4.11.5 Concrete structural section

Portland cement concrete offers good rolling resistance, durable surface cohesion, and easy maintenance (fig. 4-45). Control joints can reduce riding comfort and complicate connections to existing surfaces. For riding comfort, and to minimize deterioration of the joint, transverse joints should be saw cut. A thicker paving section may be required where heavy vehicles use or cross the path. Each such location should be evaluated and the thickness increased if appropriate.

Figure 4-45: Cross section of concrete path. Thickness and details vary according to local conditions.



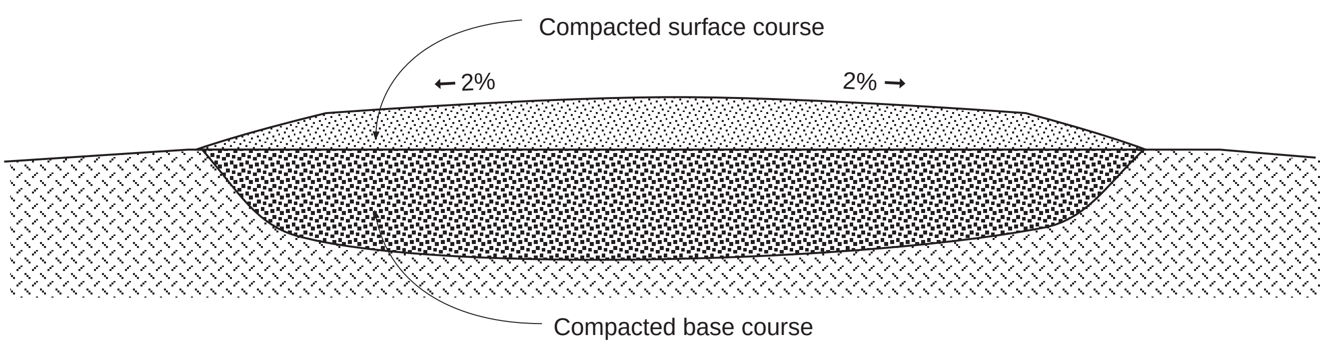
4.11.6 Aggregate structural section

Unpaved surfaces are best used where few formal traffic control measures are necessary and in natural settings. The Wisconsin Department of Natural Resources has built and maintains many miles of such paths (fig. 4-47), often following old railroad corridors. Depending on local availability, screened limestone or “rotten” granite are typically used. Crushed stone is easy to repair, does not crack and generally provides a comfortable riding surface. The popular wide-tired mountain bikes, as well as skinnier touring tires, are well-suited to such a path surface. It also integrates well into natural settings.

Figure 4-46: A crushed stone path often has a more natural appearance than pavement and is particularly good for trails following abandoned rail lines.

Some crushed stone surfaces lose cohesion with time, increasing the risk of skids. They may also be subject to erosion and vegetation encroachment. On limestone surfaces, wet weather may cause the limestone to emulsify, creating a spray from bicycle wheels which can coat the bicycle and rider. This can also be a problem for wheelchair users. And in dry weather, rising dust may hasten wear on bicycle mechanisms and make riding less pleasant. Overall, however, the surfaces work very well for recreational paths, particularly those in rural areas.

Figure 4-47: Cross section of aggregate path. Thickness and details vary according to local conditions.



Grades greater than 5% should not be surfaced with crushed stone. These sections should be paved to prevent ruts and depressions.

Figure 4-48: Well-maintained path surfaces are important for all users.

4.11.7 Surface smoothness and maintenance

Paths should be built and maintained to provide a smooth riding surface. At the same time, skid resistance qualities should not be sacrificed for the sake of smoothness. On concrete, for example, broom finish or burlap drag surfaces are preferred. Consult with a district materials or soils engineer for recommendations on proper materials and construction.

Path surfaces tend to oxidize more rapidly than highway surfaces do. As a result, the use of surface treatments (Table 4-8) may help lengthen pavement life by slowing this process. Fine aggregate seal coats, for example, can give smooth asphalt surfaces if properly designed and can extend pavement life. Routine crack sealing is also an important factor.

Table 4-8 Surface Maintenance Treatments

Surface Deterioration	*Treatment*
Moderate (Slight Raveling)*	Slurry Seal *(aggregate, asphalt emulsion and fillers)*
Serious*	Overlay; seal cracks

** Localized areas that are seriously deteriorated should be reconstructed prior to application of the seal and/or placement of the overlay. Use of seal coats may not be desirable where in-line skating, etc. occurs.*

4.12 Drainage

The recommended minimum pavement cross slope of 2% adequately provides for drainage. On curves, the cross slope should direct runoff to the inside, providing a slight amount of superelevation. Sloping in one direction usually simplifies longitudinal drainage design and surface construction, and is the preferred practice. However, some agencies prefer to crown concrete paths. And the Wisconsin Department of Natural Resources crowns its unpaved paths (see Section. 4-11-6).

Ordinarily, surface drainage from the path will be adequately dissipated as it flows down gently-sloping terrain. To this end, a smooth path surface and properly prepared shoulders are essential.

Where a shared-use path is constructed on the side of a hill, a drainage ditch of suitable dimensions should be placed on the uphill side to intercept hillside drainage. Such ditches should be offset from the pavement edge and designed with appropriate downslope from the path to the ditch (see fig. 4-14).

Where necessary, catch basins with drains should be provided to carry the intercepted water under the path. Drainage grates and manhole covers should be located outside the travel path of bicyclists. Any such structures that present a potential hazard should be offset at least 3 ft from the path edge and should be identified with hazard markings (see Fig. 4-49).

To assist in preventing erosion in the area adjacent to the shared use path, the design should include considerations for preserving the natural ground cover. Adjacent slopes should be seeded, mulched, and sodded.

On unpaved shared-use paths, particular attention should be paid to drainage to avoid erosion.

Figure 4-49: Hazard markers identify drainage structure adjacent to the path edge. If possible, such structures should be offset at least 3 feet from the edge of the path and covered with a bicycle-safe grate.

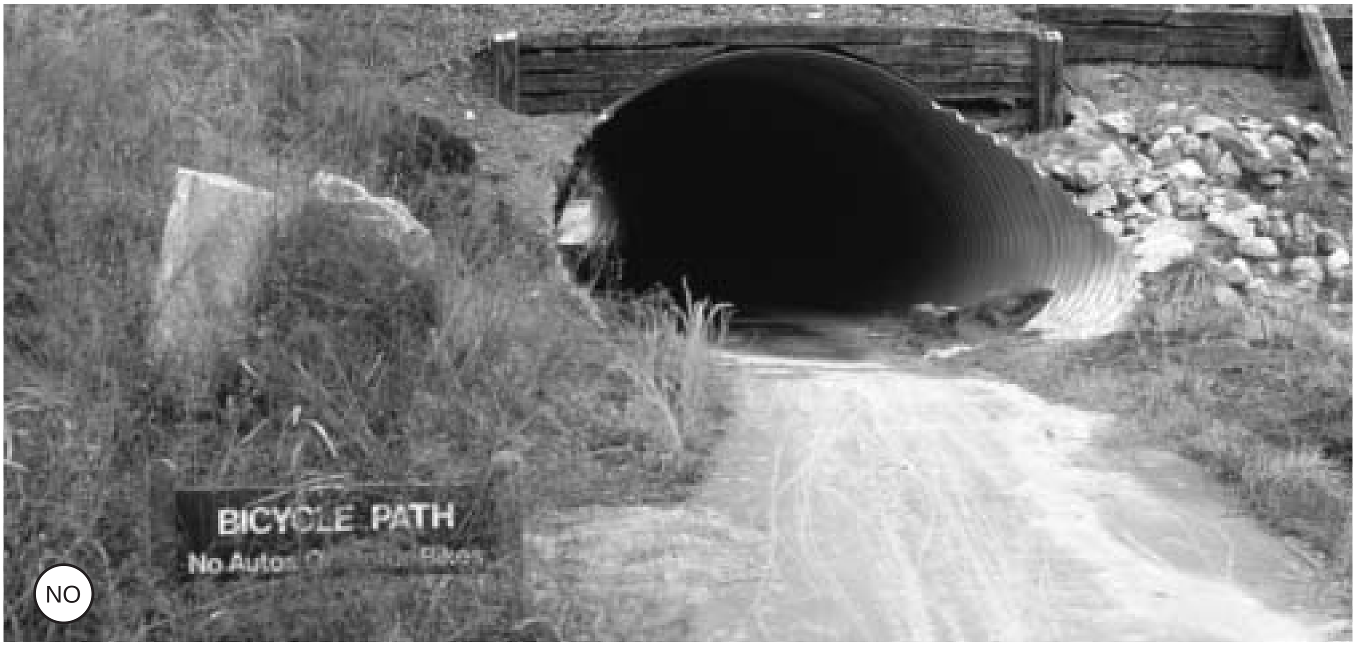


Figure 4-50: Path lighting is particularly important where ambient light levels change dramatically, as in an underpass.

4.13 Lighting

Fixed-source lighting improves visibility along paths and at intersections. In addition, lighting allows the bicyclist to see the path direction, surface conditions, and obstacles. Lighting for shared use paths is important and should be particularly considered where night usage is expected, such as on urban and suburban paths serving college students or commuters, especially those consistently serving both pedestrians and bicyclists. Even where lighting is not used for the path itself, lighting of intersections at trails and roadways should be strongly considered. Lighting should also be considered through underpasses or tunnels (fig. 4-50), overpasses, and where nighttime security could be an issue. Lighting is critical for path segments with sharp curves and grades, especially if those conditions do not meet other minimum AASHTO design requirements. This is common for ramps leading to overpasses or underpasses.

Shared-use path designers should take into consideration a number of lighting-related factors:

Figure 4-51: Path users need to see small obstacles and changes in surface to feel safe at night.

- ***Night vision:*** *Both bicyclists and pedestrians have specific requirements for nighttime seeing. Both need to see small obstacles and changes in pavement surfaces to feel safe using paths at night. Uniform illumination should be provided that avoids "hot spots" and deep shadows, and care must be taken to avoid glare, which can compromise night vision.*

- ***Illumination levels:*** *Recommended light levels for shared-use paths are considerably lower than those for roadways and other outdoor lighting applications (see Table 4-9).*

Table 4-9 Recommended Illumination for Shared-use Paths
Lux/Foot Candles
(from IESNA DG-5-1994, Table 2)

	Avg. Horizontal Illuminance Levels	*Horizontal Avg:Min*	*Average Vertical Illuminance Levels*	*Vertical Avg:Min*
Paths along streets:				
Commercial	10/1	4:1	20/2	5:1
Intermediate	5/0.5	4:1	10/1	5:1
Residential	2/0.2	10:1	5/0.5	5:1
Paths away from streets:	5/0.5	10:1	5/0.5	5:1

- ***Luminaire Design:*** *Typical pole mounted roadway lights are a poor choice for illuminating narrow paths. Standard Type II horizontal lamps create spill light off the path, and require excess wattage and/or more frequent placement to maintain uniformity. If pole mounted lights are specified, Type I horizontal lamps should be used.*

Figure 4-52: Type II horizontal lamps provide more light than is necessary.

- ***Luminaire placement:*** *Uniformity of illumination is particularly important for shared-use paths. Bicyclists moving between "hot spots" from poorly placed luminaires may be unable to see in the interspersed shadows. Providing some overlap allows for a more constant visual environment, and can help prevent crashes.*

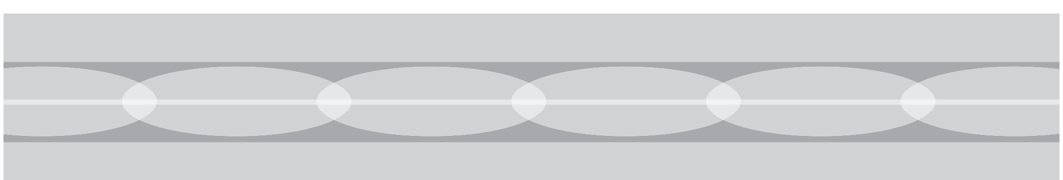
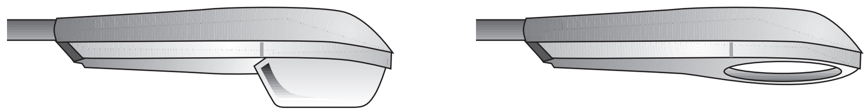


Figure 4-53: Properly spaced luminaires overlap to provide a more constant visual environment.

- ***Full cutoff:*** *Glare from cobra-style luminaires should be avoided in all cases. Particular attention should be given to pathways adjacent to residences, waterways, or natural areas* *where spill light and glare are unacceptable (fig. 4-54). Full cutoff luminaires are a minimum requirement for all path illumination, while special shielding may be required for more sensitive areas.*



Cobra - not used　　*Cutoff - used by WisDOT*

Figure 4-54: Cobra-style luminaires create spill light and glare and should not be used.

- ***Bollards:*** *Lights mounted below eye level can also be used for illuminating shared-use paths (fig. 4-55). More frequent spacing, combined with lower wattage bulbs, can meet recommended levels of illuminance and uniformity while reducing operating costs. When choosing these fixtures, select a type that eliminates glare, since bicyclists' eye level will be just above these lights. These fixtures should be placed at least 2 ft (0.6 m) from the path edge.*

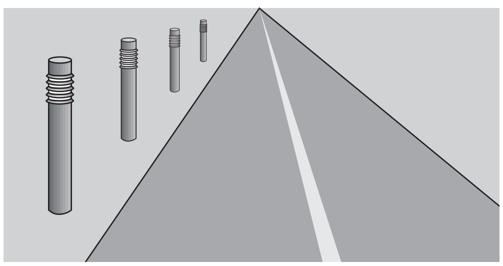


Figure 4-55: Lights mounted in bollards can provide adequate illumination while reducing operating costs.

- ***Security:*** *The ability to recognize individuals and threats to security must also be considered when designing path lighting. Good security begins with recommended levels of illumination and uniformity, but also requires consideration of bulb type and light color. For example, low-pressure sodium bulbs, while energy efficient, provide poor color rendition and compromise the viewer's ability to recognize faces. Paths through high-risk areas may require additional area lighting to provide the user with a wider view for threat detection.*

Where special security problems exist, higher illumination levels may be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances identified in Figure 4-76. Luminaires and standards should be at a scale appropriate for a pedestrian (i.e., no taller than 15 ft (4.5 m).

Note: Wisconsin State Statutes require front bicycle lights to be visible from at least 500 ft. There is no requirement for lights to illuminate the path and objects in front of a bicyclist. Many new bicycle lights are good at providing efficient lighting visible from long distances, but are relatively poor at illuminating the paths of bicyclists

Figure 4-56: Signing and marking paths are important elements of the overall design.

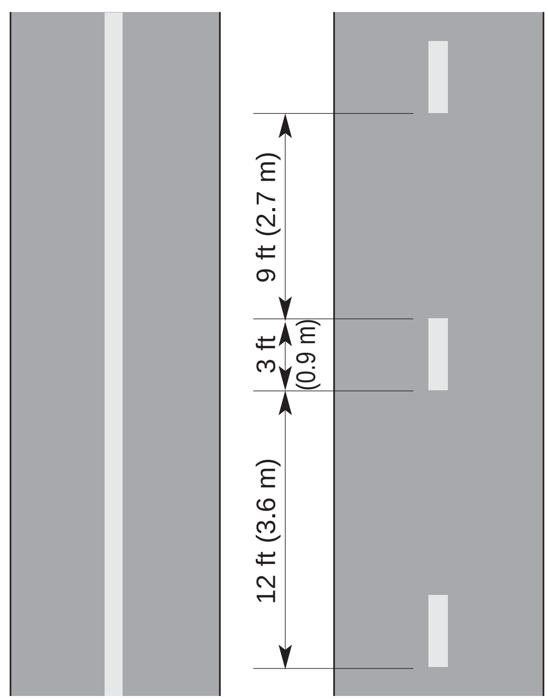
4.14 Signing and marking

Adequate signing and marking are essential on shared-use paths. And these elements fall into the same three main categories found in roadway signing and marking: regulatory, warning, and informational devices. Each category is associated with certain colors. Regulatory controls are associated with red, black, and white*; warning devices with yellow and fluorescent yellow-green; informational devices with blue, green and brown. **In striping, however, yellow is also a regulatory color.*

4.14.1 Regulatory controls

Regulatory controls alert users to a legal condition that otherwise might not be obvious. Basically, they tell people what to do.

Figure 4-57: At left is a solid yellow centerline, used where passing would be inappropriate. At right is a broken yellow line, used where passing is permitted.



Dividing users: A 4-in (100 mm) yellow center line stripe (fig. 4-57) may be used to separate opposite directions of travel. Where passing is not permitted, a solid line may be used to separate the two directions of travel. This may be particularly useful for:

- *heavy volumes of bicyclists and/or other users;*
- *curves with restricted sight distance; and*
- *unlighted paths where nighttime riding is expected.*

Where passing is permitted, a broken yellow line should be used. Broken lines should have a 1-to-3 segment-to-gap ratio. A nominal 3 ft (0.9 m) segment with a 9 ft (2.7 m) gap is recommended.

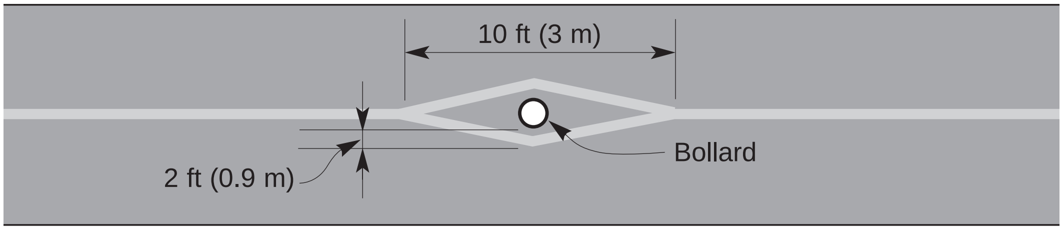


Figure 4-58: The centerline stripe should split to go around bollards.

Figure 4-59: Sign used to separate path users by type.

R5-3

Where there is a bollard in the center of the path, a, a solid yellow center-line should be split to go around it (fig. 4-58) and the bollard should be reflectorized. If designers wish to separate different types of users, a solid white line may be used. The R5-3 sign (fig. 4-59) may be used to supplement the line (fig. 4-60). For more information on separation, see Section 4.17.1. In addition, white edge lines can help where significant night-time bicycle traffic is expected (e.g., near a university campus).

Figure 4-60 (right): One approach to separating bicyclists and pedestrians. Expect only modest success with treatments that do not physically separate bicyclists and pedestrians.

Figure 4-61: The "No Motor Vehicles" sign may be used at the entrance to a shared-use path.

R5-3

Excluding unwanted users: Typically, unauthorized motor vehicles are prohibited from shared-use paths. The No Motor Vehicles (R5-3) sign may be installed at the path entrance (fig. 4-61). Where other potential users are prohibited (e.g., horses, pedestrians, motor-driven cycles, etc.), appropriate combinations or groupings of these legends into a single sign may be used. These are described in Section 2B.31 of the MUTCD. Other means to discourage motor vehicles are discussed in Section 4.17.3.

Establishing right of way at intersections: Regulatory signs and markings are typically used to assign right of way at intersections, whether at path/path crossings or at path/roadway crossings.

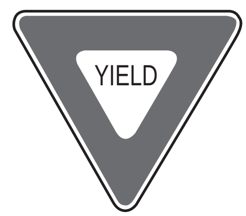
Assigning right of way is done primarily through signage, the Stop sign (R1-1) being the most common. In addition, a Stop line pavement marking may be used to show where one should stop. While relatively uncommon in areas with substantial snowfall, a "Stop" word marking is also occasionally used. See also Section 4.15 on crossings.

Figure 4-62: The intersection of a path and roadway; in this instance, the path has the stop sign

Stop signs are used where those on one leg (or more) of an intersection are required to stop and yield to others. Yield signs (R1-2) are used at points where those on one leg (or more) of an intersection are required to yield the right-of-way to conflicting traffic — and where they have an adequate view as they approach the sign (fig. 4-63). Where they do not have an adequate view, Stop signs are generally used.

Figure 4-63: The "Stop" sign and "Yield" sign are used to assign right of way.

R1-1



R1-2

When considering Stop sign placement, priority at a shared-use path/roadway intersection should based on the following:

- *relative speeds of shared-use path and roadways users;*
- *relative volumes of shared-use path and roadway traffic;*
- *relative importance of shared-use path and roadway;*
- *if the path crosses the highway in a perpendicular fashion (mid-block style crossing) or crosses the legs of an intersection as a sidepath does.*

Speed should not be the sole factor used to determine priority, as it is sometimes appropriate to give priority to a high-volume shared-use path crossing a low-volume street, or to a regional shared-use path crossing a minor collector street.

When assigning priority, the least restrictive appropriate control should be placed on the lower priority approaches. Stop signs should not be used where Yield signs would be acceptable. Where conditions require bicyclists, but not drivers, to stop or yield, the Stop sign or Yield sign should be placed or shielded so that it is not readily visible to drivers.

Limiting speed: Some agencies have used speed limit signs and/or markings in an attempt to keep bicyclist speeds down. Since most bicycles don't have speedometers, however, there is some question about the effectiveness of such an approach. Instead, warning signs and pavement markings, as described in Section 4.14.2, may be more appropriate.

Figure 4-64: Warning signs let bicyclists know what to expect.

4.14.2 Warning devices

Warning devices are used to alert users to hazardous (or potentially hazardous) conditions on or adjacent to a shared-use path. They are also used to let others (e.g., motorists on a cross street) know about the presence of the path and the potential for conflicts (fig. 4-86) . Warning devices require caution on the part of users and may require them to slow. If used, advance bicycle warning signs should be installed no less than 50 ft (15 m) in advance of the beginning of the condition.

Hazardous conditions: Warning signs and markings let path users know about problems like tight curves, low clearances, obstacles, and other hazards. Typically, these are permanent conditions that cannot be easily corrected. The signs below are examples of such devices.

Figure 4-65: Common hazard warning signs used on shared-use paths.

W1-5 W12-2 W5-4 W7-5

W2-1 W10-1 W11-1

Figure 4-66: Typical warning signs related to crossings and traffic controls. The W2-1 and W10-1 signs would be used on the path, while the W11-1 would be used on a roadway to warn motorists of a path crossing.

Traffic controls and intersections: In advance of traffic controls and intersections, it may be helpful to place warning signs that alert users to the specific conditions (fig. 4-66). These are particularly applicable where the situation is not apparent (e.g., an intersection around a curve).

Figure 4-67: Informational signs on paths often take on the character of the area or the path's namesake.

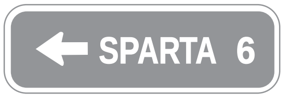
4.14.3 Informational devices

Information signs and markings are intended to simply and directly give users essential information that will help them on their way. They guide path users along paths; inform them of interesting routes; direct them to destinations; and identify nearby rivers, streams, parks, and historical sites.

M1-9

Figure 4-68: The "Numbered Route Sign" is used to connect routes between states.

Directional aids: Bicyclists often find it helpful to know where a path goes, how far certain destinations are, and if the section of a path has a route name or number. In general, names are preferred to numbers for routes because they are more descriptive and need less interpretation. For example, "Elroy-Sparta" (fig. 4-67) says more than "Route 23" (fig. 4-68).



D1-b(L)

D1-b(R)

D1-1(c)

Figure 4-69: A variety of destinational and directional signs help to make paths more useful.

Signs that show destinations and distances are also helpful (fig. 4-69). These can help bicyclists decide if they have the time or energy to continue to a certain destination or whether they need to change their plans.

Similar signs that identify crossroads are also helpful, particularly along paths that follow their own rights-of-way. Without these, it may be difficult to tell where one is. A path following a river or creek, for example, may cross under many surface streets but from below, these streets may not be recognizable without a sign visible from the path.

Figure 4-70: An orientation sign that gives the user a sense of where he or she is.

At major trailheads, agencies may post larger signs with maps of the entire system or of the specific corridor (fig. 4-70). These help users orient themselves and identify landmarks like picnic areas, visitors' centers, and restrooms. Often, such signs also include path system rules and restrictions.

Another device often found on path systems is the distance marker (fig. 4-71). On highways, these take the form of “Reference Posts” found every mile, but on paths shorter increments are more appropriate. Markers every quarter or half mile may better suit the path environment and the casual users. Such markers are helpful for the user and maintenance worker, but may be critically important for police and others responding to an emergency.

Figure 4-71: Several designs for distance markers. These and other path enhancements can be designed to fit in rather than stand out.

Cultural markers: Markers may be used to identify special features (fig. 4-72). A path may follow a historically-significant abandoned railroad line or canal that once carried heavy traffic; or it may pass by an old town site or an important wildlife habitat. The markers typically describe the area and its significance and may include photos or other illustrations.

4.14.4 Temporary work zone controls

Agencies use temporary traffic control signs to help motorists get through or around a work zone. The same approach should be taken for shared-use path users (fig. 4-73, 4-74). Putting a barrier across a path without warnings and directional aids can create a hazard, particularly for bicyclists riding at dusk or at night. *[Bicycle lights are required in Wisconsin, but the law says lights only have to be seen from a distance of 500 ft.]*

Figure 4-72 (above): Sites with cultural or historical significance make interesting features of a shared-use path and should be identified for users.

Each temporary traffic control zone is different. Many variables, (e.g., location, user speeds, lighting) affect the needs of each zone. The goal is safety with minimum disruption to users. The key factor in promoting temporary traffic control zone safety is proper judgment.

Since path speeds are much lower than highway speeds, however, the needs tend to be much simpler. In many cases, an advance warning sign on either end of a work zone with proper directional aids to a safe detour and, if necessary, lighting to illuminate any barriers or hazards will suffice. See the MUTCD for more detailed advice on traffic control zones, in general.

Figure 4-73 (top left): Just as temporary detours and road closure signs are used on roadways, similar attention should be paid to the needs of path users.

Figure 4-74 (lower left): Work zone safety is a part of every significant path reconstruction or repair project.

4.14.5 Placement of signs

Signs on shared-use paths should be placed where they are clearly visible to users but do not, themselves, pose a hazard (fig. 4-75). Signs must be at least 3 ft (0.9 m) but no more than 6 ft (1.8 m) from the near edge of the path. Mounting height for ground-mounted signs must be at least 4 ft (1.2 m) but no more than 5 ft (1.5 m), as measured from the bottom edge of the sign to the near edge of the path surface (fig. 4-76).

For overhead signs, the clearance from the bottom edge of the sign to the path surface directly under the sign must be at least 8 ft (2.4 m). *The clearance may need to be increased to allow typical maintenance vehicles to pass beneath.*

Figure 4-75: Warning signs offset from the path's edge for safety.

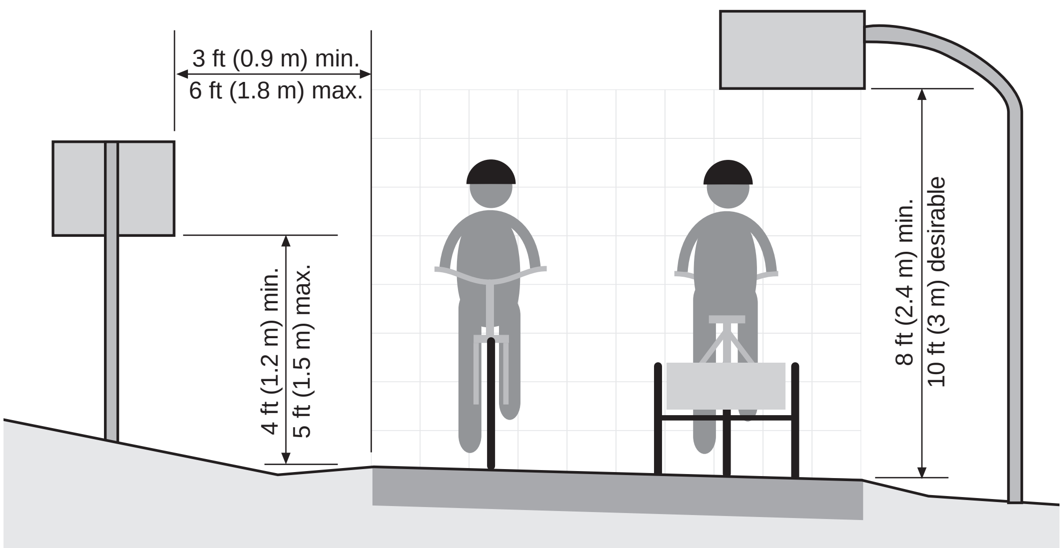


Figure 4-76: Clearances between the path and adjacent or overhead signs.

Figure 4-77: Where there is no alternative, a shield may be used to keep motorists from seeing a sign for path users.

Signs for exclusive use of bicyclists should be located so that drivers are not confused by them. If necessary, shielding should be used to keep motorists from seeing them (fig. 4-77). If the sign applies to drivers and bicyclists, then it should be visible from both perspectives.

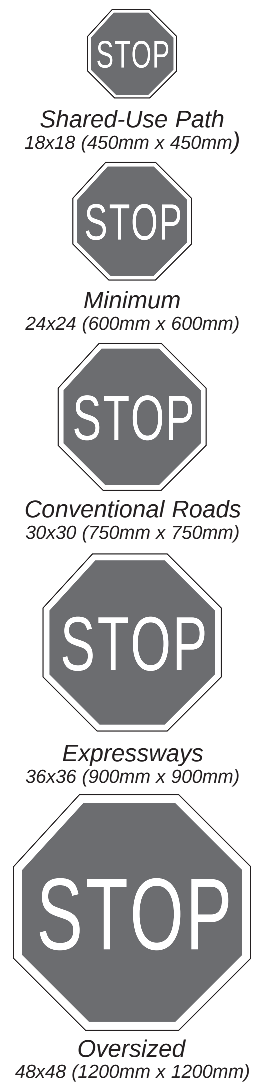
For more information on the use of signs and markings at intersections, see Section 4.15.

Figure 4-78: Shared-use path signs are smaller than their counter-parts on roadways.

4.14.6 Sizes of signs

Shared-use path signs are smaller than similar signs used on various roadways (fig. 4-79). The appropriate sizes for path signs are given in the MUTCD (Table 9B-1). Signs in shared-use path sizes are not to be used where they would have any application to other vehicles. Larger size signs may be used on shared-use paths where appropriate.

Figure 4-79: Comparative sizes of stop signs.



4.14.7 Using restraint

Restraint in signing and marking shared-use paths is generally appreciated. Few path users want their off-road experience to exactly mirror the on-road environment. As an example, the use of warning signs at properly designed curves is generally unnecessary and intrusive. And such things as mile markers, path names, and historical markers can be designed to fit with the path's location or theme.

In areas where pavement markings are cost-effective, using them in conjunction with warning or regulatory signs at critical locations may be appropriate. Otherwise, theft of warning or regulatory signs may leave bicyclists unaware of serious hazards or their legal duties in a particular situation.

Care should be exercised in the choice of pavement marking materials. Some are slippery when wet and should be avoided. Product choice should consider skid-resistance, particularly at locations where bicyclists may be leaning, turning, or stopping.

This advice on signing and marking should be used in conjunction with the Manual on Uniform Traffic Control Devices (MUTCD).

Figure 4-80: A challenging location to develop a crossing.

4.15 Path-Roadway Crossings

Roadway crossings can present some of the most difficult challenges in shared-use path design. Due to a wide variety of potential conflicts, optimal location and careful design are of paramount importance to the safety of path users and motorists alike. Historically, some designers have attempted to force bicyclists to stop, dismount, and walk across at crossings. However, experience has shown that such an approach seldom works. Ultimately, a good design is based on balancing the safety and convenience of all users in a fair and reasonable manner.

Fig. 4-81: A shared-use path follows a river corridor and takes full advantage of a grade separation with a freeway.

The crossing strategies discussed in this section should be considered basic guidelines, not absolutes. Each crossing is unique, with its own geometrics, traffic characteristics, and constraints. As a result, sound engineering judgment is a key ingredient to a successful solution.

4.15.1 Choosing crossing locations

Difficult crossing design problems can sometimes be avoided or simplified by paying careful attention to location. At a network planning scale, choosing a corridor with the fewest obvious conflicts can solve many problems. For instance, choosing to build on a rail-trail or within a river corridor (Fig. 4-81) can eliminate some intersections entirely. Conversely, placing a path along an urban street will introduce path users to many side-street intersection and driveway conflict points.

At the project level, path alignment may be shifted to avoid a hazardous location (e.g., a blind highway curve or busy intersection). Figure 4-82 shows an example with two possible alignments, one with a serious sight obstruction.

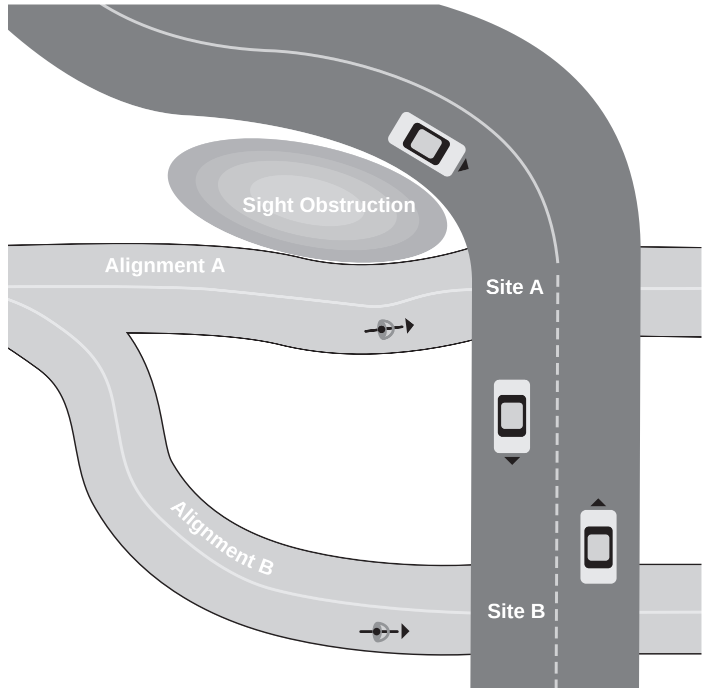


Fig.ure 4-82: Proper path alignment can help eliminate sight obstructions. Alignment "B," for example, gives a better crossing location than does alignment "A."

Path intersections and approaches should be on relatively flat grades. A steep incline with a stop sign at the bottom will make it difficult for less experienced bicyclists to stop in time. And such an incline will increase the path's design speed and the stopping sight distance.

Unwary bicyclists may not begin slowing down soon enough to safely come to a stop (fig. 4-83). They may brake too hard and crash or ride into the intersection without being able to stop, particularly in wet or icy conditions. If such conditions cannot be avoided, advance warning signs and increased stopping sight distances should be provided.

For these reasons, providing an appropriate length of level path before the intersection will allow bicyclists to slow down. *See Section 4.9. for a discussion of path runout distances at the bottom of grades.*

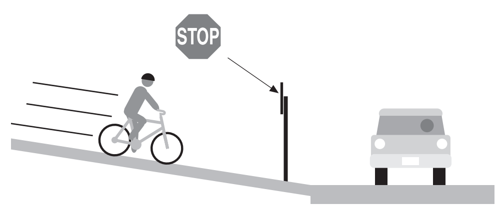


Figure 4-83: Path roadway intersections should not be placed at the bottom of a grade.

4.15.2 Intersection: yes or no?

When deciding how to handle a path/roadway crossing, the first step is an obvious one: determine whether an intersection or a grade separation is the answer. On the one hand, choosing an intersection approach involves addressing how bicyclists and motorists will interact at the crossing — who must yield to whom; whether there are sufficient gaps in roadway traffic; what roadway and traffic control changes may be required; and so on.

On the other hand, choosing a grade separation eliminates the intersection entirely, as mentioned in the previous section. It may, however, require designers to find an accessible site that will accommodate the ramps and structure.

Figure 4-84: A grade separation is the only option for getting path users across a controlled-access freeway.

If the roadway to be crossed is a controlled-access freeway, there is no decision to be made; the crossing must be grade separated. The questions remaining involve where to put the grade separation, whether to go over or under, and whether it can safely be combined with a surface street crossing (see Section 4.15.17).

At the other end of the spectrum, crossing a quiet residential street (fig. 4-85) or low-traffic rural road (fig. .4-86) would almost never warrant a grade separation. The only situation where one would likely make sense would be if the path corridor was already lower or higher than the street or there were significant sight limitations at the intersection. Examples include below-grade railroad right-of-ways or waterways.

Figure 4-85: A low-volume residential street crossing needs very little special attention.

4.15.3 Rural vs. urban/suburban locations

Between the extremes, the decision to create a path/roadway intersection or a grade separation first involves whether the crossing is rural or urban/suburban in character. Typical differences include traffic speeds, path and roadway volumes, roadway geometrics, surrounding development, and likely path users.

Figure 4-86: A shared-use path crosses a rural low-volume highway. Signing and marking, combined with good sight distance, are the primary requirements.

4.15.3.1 Rural path crossings

Rural paths typically cross high-speed roadways with a wide range of traffic volumes. Where volumes are low, crossing distances are moderate, and sight distances are good, little is required beyond basic signing and marking (fig. 4-86). In some cases, the crossing location may need to be shifted to improve sight distance (see Section 4.15.1).

Crossing moderate-volume rural highways, on the other hand, may require more extensive provisions, depending on the path's proximity to a community or recreational area and likely level of use. In some cases, a combination of signs, pavement markings, and a median refuge may be adequate. The refuge (see Section 4.15.4.2) allows bicyclists to cross half of the roadway at a time (fig. 4-87). Traffic signals, however, are seldom appropriate for rural path crossings, due to relatively low path volumes and high highway speeds.

Figure 4-87: A path crossing at a moderate volume highway combines a raised median refuge with signing and marking.

Figure 4-88: A grade separation takes bicyclists under a moderately busy highway. Sightlines are good and the entry and exit grades are slight.

Rural grade separations: In some cases, a grade separated crossing is the best option for rural highways, keeping path users completely away from the highway environment (fig. 4-88). If provided, care must be taken to assure that the grade separations, themselves, are designed for the safety of the path and highway user; structures, for instance, must meet applicable highway clear zone requirements.

Typical examples of grade separation options include:

- *taking advantage of railroad rights-of-way (fig. 4-67) or river corridors that provide "natural" grade separations;*
- *shifting path alignment to an existing grade separated road-way crossing.* For example, if a minor road goes over or under the highway, it may provide a safe option (see Section 4.13.3 for cautions about mixing path traffic and roadway traffic);
- *providing a properly-sized box culvert for the path.* This can be a relatively economical option if ramps with proper slopes can be provided and adequate clearances for path users and maintenance vehicles are maintained (fig. 4-37); and
- *providing an overpass or underpass bridge structure.* These may be expensive and should be used where most needed. In some cases, grade separations may be provided as part of a highway improvement project.

Determining whether a rural grade separation is needed involves looking closely at the characteristics of the crossing location. The Wisconsin Department of Transportation has developed a process for analyzing traffic volumes and speeds to determine which rural crossings need grade separations and is included in FDM 11-55-15. The approach involves first determining if the roadway meets basic thresholds for consideration:

Minimum requirements for rural grade separation:

- *The minimum highway Annual Average Daily Traffic (AADT) should be 3500 or greater.* This threshold is a starting point, but does not preclude looking at highways with less than 3500, should it be necessary.
- *Rural posted speed limits should be between 40 and 55 mph.*

If these warrants are met, the designer then conducts hourly path and roadway traffic counts (projected path counts may be used if necessary). From these, a gap analysis, similar to that described in the MUTCD's warrants for traffic signals, is prepared. An "exposure factor" is derived by multiplying the hourly volumes for path traffic by the roadway traffic volume for the same hour.

Exposure factor: *Path Hourly Traffic Volume X Roadway Hourly Volume (for same hour)*

The highest and fourth highest exposure factors are then used to determine the necessity of a grade separation:

Table 4-10 Path-Highway Crossing Guidance for Rural 2-lane Highway Facilities

Grade Separation Alternatives

Hourly Exposure Factor (in 1000s)	Does Not Meet WisDOT Warrants	May Be Justified	Meets WisDOT Warrants
4th Highest Exposure Factor	<25	25-35	>35
Highest Exposure Factor	<40	40-60	>60

Note At-grade trail crossings are undesirable on multi-lane rural expressways. Evaluate these locations on a case by case basis.

For a copy of the Wisconsin DOT guidance, see "Permanent Public Trails Crossing Rural Roads in FDM 11-55-15.

Figure 4-89: Urban and suburban paths often need to cross arterial and collector streets.

4.15.3.2 Urban/suburban path crossings

In more developed areas, crossing designers must consider a wide variety of constraints. More so than is often true on rural paths, urban and suburban path crossings require designers to balance numerous competing needs and constraints while providing a facility that is safe and convenient.

Common urban/suburban path crossing constraints and challenges:

- *There is often little potential path right-of-way in built-up areas; as a result, options for developing good crossings may also be limited.*
- *Roadways are often wider and may have numerous intersections and dedicated turn lanes (fig. 4-90).*
- *More of the urban and suburban streets may carry substantial levels of traffic than rural roads.*
- *Nearby shopping areas may have numerous busy commercial driveways intersecting the roadway.*
- *Path right-of-way may pass between buildings or other structures and, as a result, present no possibilities of shifting one way or another.*

Figure 4-90: Existing grade differences made it relatively easy to carry this rail-trail above a major suburban arterial street.

At the same time, urban and suburban path crossings may present opportunities not available in most rural areas.

Common path crossing opportunities:

- *With the exception of urban freeways, expressways, and some major suburban arterial streets, traffic speeds are significantly lower than on rural roads and highways.*
- *A crossing may be coupled with a nearby signalized intersection to provide an easier way across a major arterial street.*
- *Redevelopment may open up new corridors.*
- *An adjacent landowner (e.g., a university) may help fund an expensive crossing.*
- *The proximity of larger numbers of potential users may make an expensive path crossing easier to justify than a similar crossing on a lightly-traveled rural path.*

The Wisconsin Department of Transportation has not, at this time, developed a warrant process for judging the necessity of urban or suburban grade separations. The complexities of many crossings make it difficult to develop a comprehensive set of warrants. At the same time, an analysis of traffic volumes, similar to that used for rural crossings, would be useful in understanding the challenges presented by a crossing opportunity. If gaps in cross traffic are frequent, developing a grade-level crossing would likely be feasible. If they are rare and providing a signalized crossing is not possible, a grade separation may be the only way to go.

The following options cover the range of likely urban or suburban crossing situations and the general character of the solutions:

- *crossing low-volume streets* requires little more than basic improvements – stop or yield signs, warning signs, and pavement markings;
- *crossing medium-volume streets* may combine signs and markings with median refuges;
- *crossing high-volume streets* may require a signalized intersection and/or a median refuge; and
- *crossing very-high volume streets* will likely require a grade separation; freeways do require one.

These points may perhaps be better understood in the form of a graphic. Figure 4-91 summarizes some of the factors to consider in the decision.

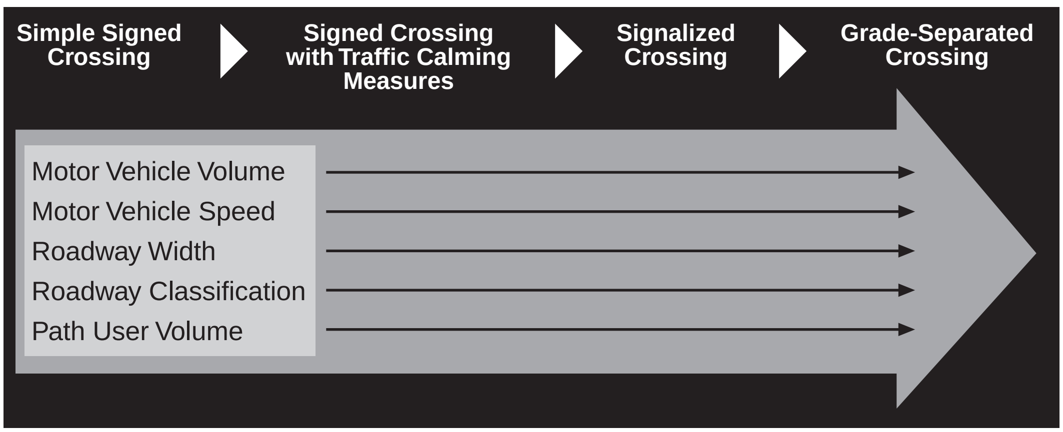


Figure 4-91: As the complexity of a path/roadway crossing situation increases, the crossing design must change also.

4.15.4 Crossing design

In this section, each crossing situation is described in greater detail in order to facilitate the design process. While the following discussion covers the primary points of interest, additional guidance is available. The report *Trail Intersection Design Handbook* (Florida DOT, 1996) has additional information to help the crossing designer.

Figure 4-92: A well-designed combination path and street crossing requires doing more than adding push buttons.

Combining path and street crossings

If the path is close to an existing roadway intersection, a combined path/roadway crossing may be necessary — and may work well if conflicts with turning traffic can be minimized (see Section 4.15.5). If this is not possible, the path alignment may need to be reconsidered or the intersection reconfigured.

Figure 4-93: A basic signed crossing includes traffic controls, warning devices (signs and markings), and good sight distance.

4.15.4.1 Simple signed crossing

A simple signed crossing is most appropriate on low-volume residential streets (fig. 4-93) or quiet rural town roads (fig. 4-94). It typically includes the following elements:

- *Traffic controls for either path or road traffic, depending on which should have priority (see Section 4.14.1);*
- *Adequate sight distance (based on traffic speeds); and*
- *Warning devices to alert path and roadway users.*

Figure 4-94: This rural crossing has excellent sight distance for both motorists and bicyclists. Signing and marking make it clear what to expect.

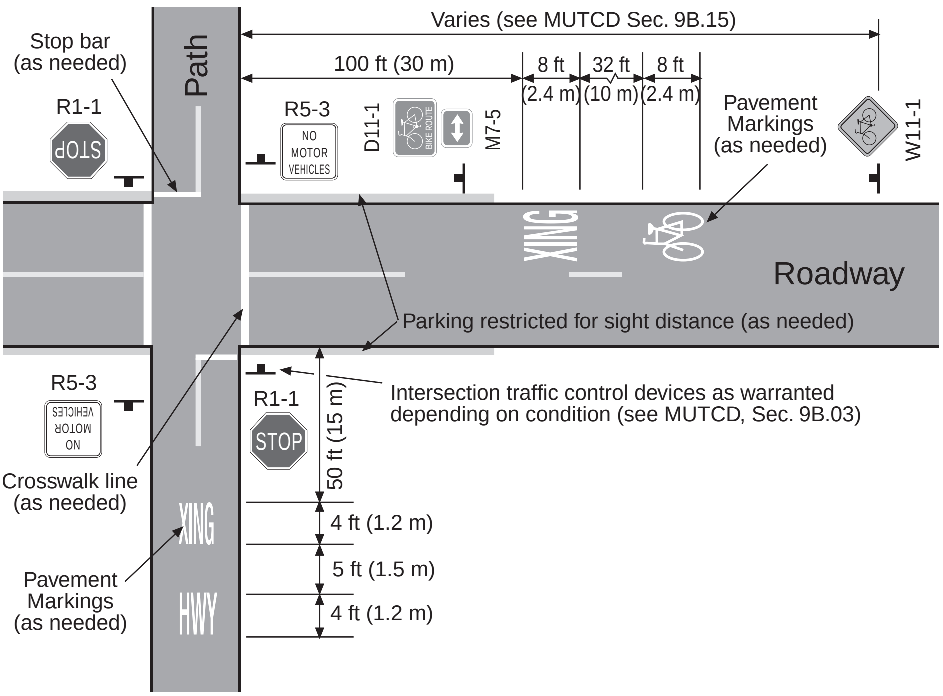


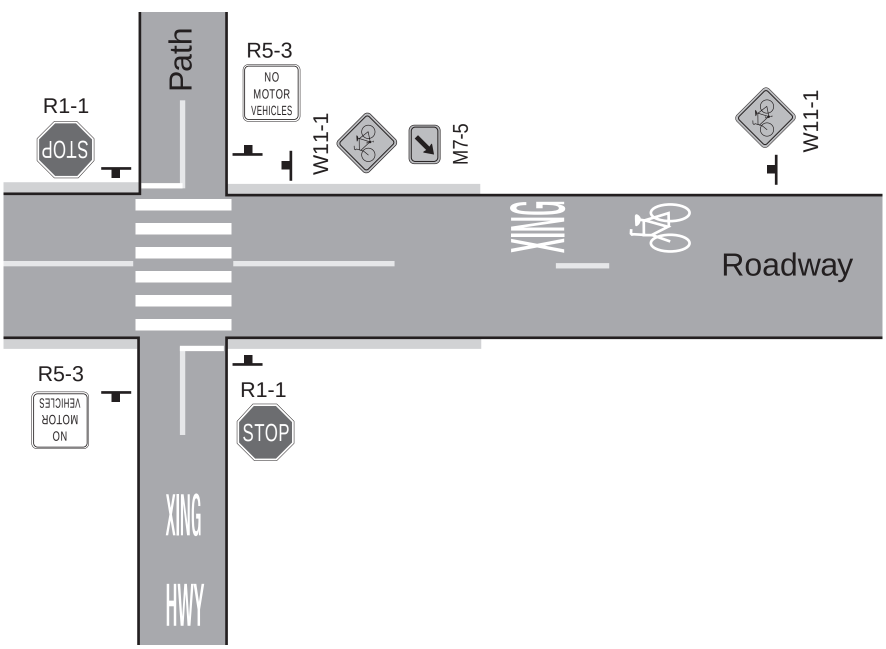
Figure 4-95: Typical signs and markings for path crossings (after Fig. 9B-3, MUTCD, 2000)

Figure 4-95 shows the elements of a crossing. Not every one is needed in each instance – the decision should be based on sound engineering judgement. For example, on low-volume residential streets, Bike Xing or Hwy Xing pavement markings or advance Bike Crossing signs may not be necessary if sight distances are good and speeds low. The Bicycle Route sign (D11-1) is an option as well.

On crossings of neighborhood collector streets and minor county trunk highways, a higher level of attention may be needed. In addition to the regulatory and warning devices shown in Figure 4-95, crosswalk stripes may be increased in width to as much as 24 in (0.6m).

Alternative crosswalk patterns, such as diagonal or longitudinal striping (fig. 4-96), may also be used (see MUTCD, Sec. 3B.17), as may two sets of W11-1 Bicycle Crossing warning signs: one at the crossing with a diagonal arrow subplate (W16-7) and the other in advance of the crossing. Crossing signs may also use a fluorescent yellow-green background.

Figure 4-96: Extra emphasis may be needed at some crossings.



For intersections with quiet, low-speed streets (≤25 mph), one option may be to create a raised crossing (fig. 4-97) or speed table. See Section 2.10.2 for more information on speed tables.

Figure 4-97: A raised path crossing used to slow motorists and give path users priority.

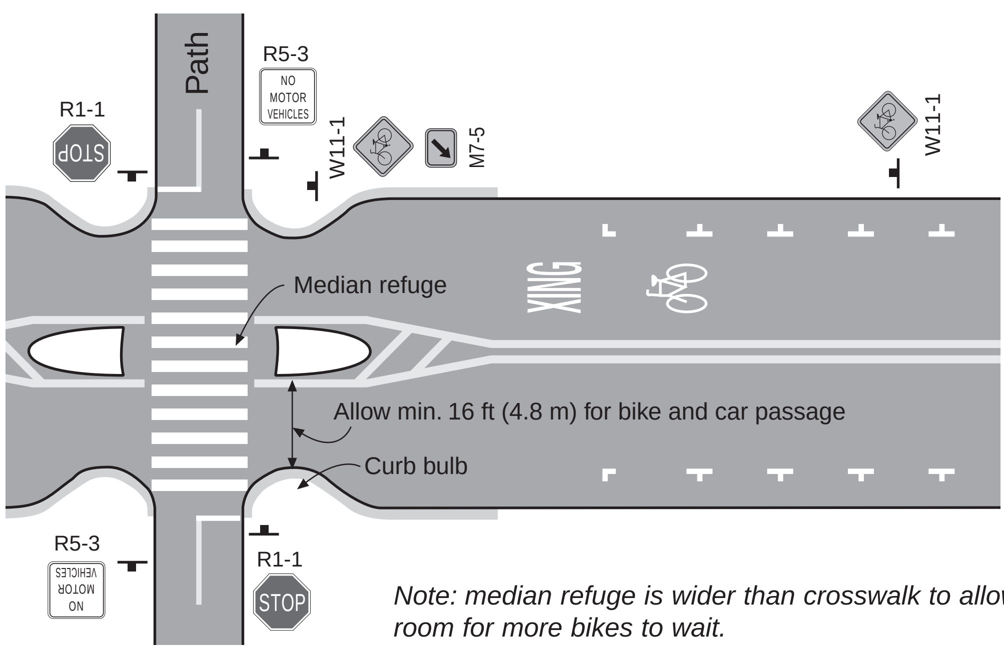
Figure 4-98: An at-grade path crossing of a low-volume rural roadway. Note damage to bollard; see Section 4.17.3 for alternative approaches to discouraging motor vehicle intrusion.

Figure 4-99: Traffic calming measures can make a significant difference in how easily path users can get across a roadway.

4.15.4.2 Signed crossings with traffic calming measures

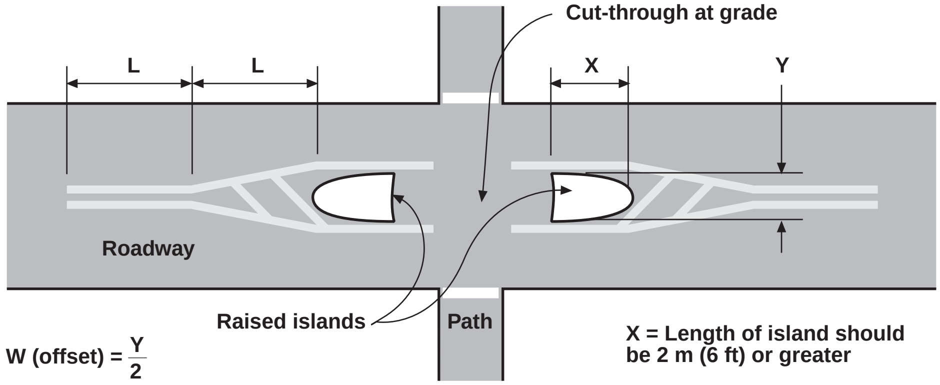
Traffic calming measures can help path users cross minor or major arterial streets (fig. 4-99), county trunk highways, or multi-lane roadways. Such measures can help slow traffic or reduce the crossing distance. In addition to elements mentioned previously, one or more of the following may be appropriate:

- *Median refuges (fig. 4-100) between opposing directions of roadway traffic; and*
- *Curb bulbs extending into the roadway reduce crossing distance (applicable where an on-street parking lane is provided);*



Note: median refuge is wider than crosswalk to allow room for more bikes to wait.

Figure 4-100: Features like curb bulbs and/or median refuges are among the traffic calming measures that can be applied to a path crossing.



For Metric Units:

$L = \frac{WV^2}{155}$, where $V < 70$ km/h

$L = 0.62WV$, where $V \geq 70$ km/h

For English Units:

$L = \frac{WV^2}{60}$, where $V < 45$ mph

$L = WV$, where $V \geq 45$ mph

Y = Width of refuge:
6 ft (2.0 m) = poor
8 ft (2.5 m) = satisfactory
10 ft (3.0 m) = good

Figure 4-101: Basic elements of a median refuge. (After Fig. 23, Guide for the Development of Bicycle Facilities, AASHTO, 1999; and fig. 22, Trail Intersection Design Handbook, FLDOT, 1996.).

Median Refuges: Generally, it is easier for path users to cross one half of a busy road at a time. As a result, median refuges can reduce path user delays and clearance intervals. And, they give users a place to wait in relative safety until motor vehicle traffic clears. Raised medians are preferred over paint-delineated areas; the latter may be used by some motorists as storage areas for left turns.

Refuges may be cut through the island (fig. 4-101) or may include curb ramps to take users up to the island level. The former is more advantageous, since the entire width is available for users waiting to cross. Curb ramps, on the other hand, can significantly reduce the level waiting area, a limitation of particular concern to bicyclists and wheelchair users.

Curb bulbs: Curb bulbs, or extensions reduce crossing distances for path users, thus reducing the time they are exposed on the roadway, With 8 ft (2.5m) extensions on each side, for example, crossing time for pedestrians may be reduced by 3 to 5 seconds, depending on walking speed.

Bulbs also visually and physically narrow the roadway, encouraging motorists to drive more slowly. And curb bulbs can prevent motorists from parking in — or too close to — the crossing.

Curb bulbs should only be used where there is an on-street parking lane and should extend into the roadway no more than the width of the parking lane. They must not extend into travel lanes, bicycle lanes, or shoulders.

Figure 4-102: Some path users need extra time to cross a roadway. Curb bulbs and median refuges help them, in particular.

Figure 4-103: An independent signalized crossing for a suburban path. (Note dark, marginally-reflectorized bollards — a hazard, particularly under low light conditions.)

4.15.4.3 Signalized crossings

A signalized crossing may be necessary where a path crosses a major arterial street or a suburban highway. While there are currently no warrants for path crossing signals, the report *Trail Intersection Design Handbook* (Florida DOT, 1996) notes the following:

> *Traffic signals are appropriate under certain circumstances, with warrants for installation as discussed in the MUTCD. Though none of the 11 warrants specifically address trail crossings, they could be used since the bicycle is considered a vehicle, and trails could be functionally classified…*
>
> *The signal actuation mechanism (fig. 4-104) should be mounted beside the trail 4 ft (1.2 m) above the ground and easily accessible. This enables the bicyclist to activate the signal without dismounting. Another method of activating the signal is to provide a detector loop in the trail pavement, though this works only for bicyclists.*

On signalized roadways with a median refuge, a push button should also be provided at the median in order to serve slower path users who may otherwise be trapped in the middle of the road. Some situations may warrant flashing yellow warning lights after an engineering analysis and appropriate permitting by state and local authorities.

At some crossing locations, where optimum progression is not a factor, the designer may consider giving the path user a "hot response" or immediate call, to encourage bicyclists with the shortest possible wait. This feature will likely increase the number of path users that wait for the signal.

Figure 4-104: Path users need a way to trip the signal. If a loop detector is used for bicyclists, a push button for pedestrians should also be provided. Alternative means of detection (e.g., infrared) have been used for such purposes.

Where paths cross multi-lane roadways, visibility between the path user and the motorist in the far lane (fig. 4-105) can be blocked. For this reason, stop lines should be placed in advance of the crosswalk, the distance being based on traffic speeds. *Note: on this topic, Section 3B.16 of the MUTCD, says that "Stop lines at midblock signalized locations should be placed at least 40 ft (12 m) in advance of the nearest signal indication."*

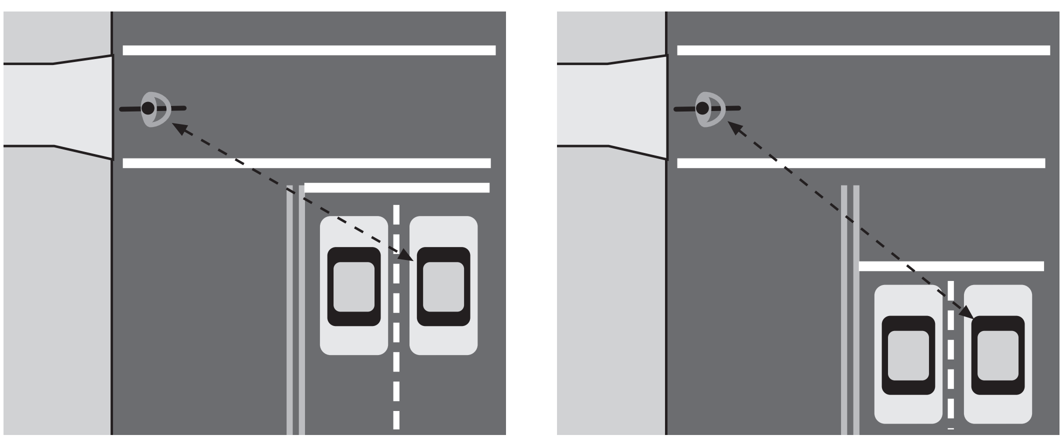
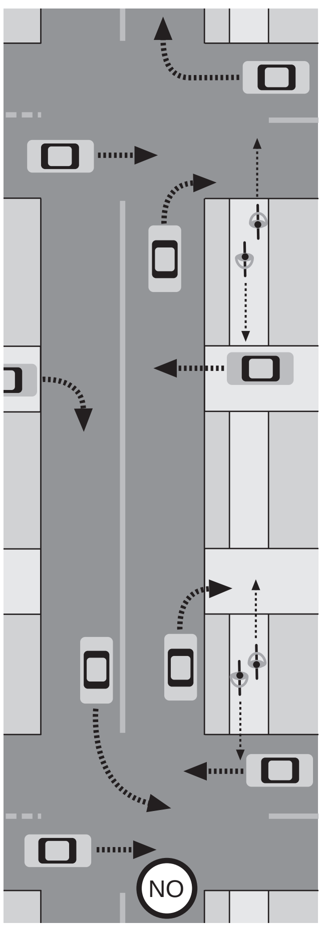
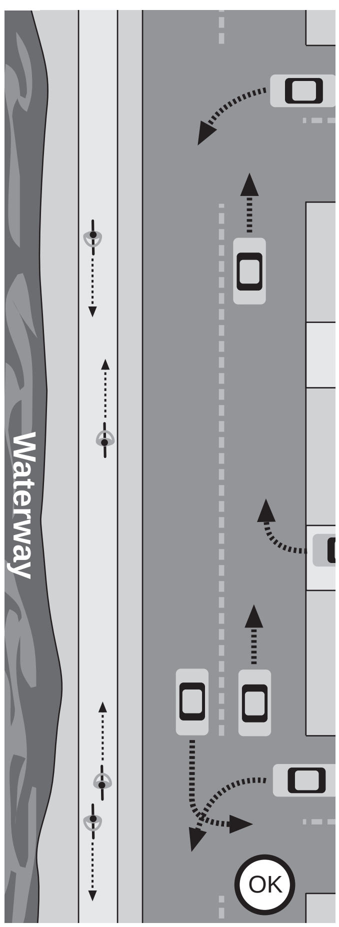


Figure 4-105: Offsetting the stop line away from the crossing will improve visibility between motorists and path users. (After figs. 29, 30, Trail Intersection Design Handbook, FLDOT, 1996.)

Figure 4-106: An urban crossing that takes advantage of an adjacent signalized intersection. A bicycle signal loop detects bikes to change the signal. Note high-visibility crosswalk marking.

Figure 107: (below left) A path with many crossings increases conflicts; (below right) a path with few crossings reduces conflicts.





4.15.5 Parallel Path Crossings

A parallel path is one that is adjacent to a roadway. Because of this relationship, the path typically intersects most of the same streets and driveways that the road, itself, does (fig. 4-107 and see Section 4.3 for more information).

An important exception occurs where cross streets form a "T" intersection and stop short of the path, as where the path follows the shore of a river or lake (fig. 4-106, right). This situation, with its somewhat limited crossing conflicts, is a characteristic of the most desirable parallel path locations.

As a general rule, the more often a parallel path crosses intersecting streets and driveways, the greater the likelihood of crossing conflicts between bicyclists. Similarly, the more traffic that enters or leaves the cross streets or driveways, the worse the situation.

Note: Some agencies have attempted to solve this problem by placing Stop signs for bicyclists at every intersection, even if the parallel roadway has priority over crossroads.. This approach damages the path's utility and encourages a "scoff-law" attitude among those riding it.

Further, Wisconsin State Statute 346.803(b) requires bicyclists to "obey each traffic signal or sign facing a roadway which runs parallel and adjacent to the bicycle way." As a result, stop or yield conditions for bicyclists on parallel sidepaths should generally be consistent with the traffic controls imposed upon traffic of the adjacent roadway.

Where the path crosses intersecting roads (and, to a lesser extent, driveways), the potential conflicts facing path users (fig. 4-108) primarily come from drivers turning left (A) and right (B) from the parallel roadway, and entering from the crossed roadway (C, D, E). In addition, path users can be coming from either direction (F, G) on two-way paths.

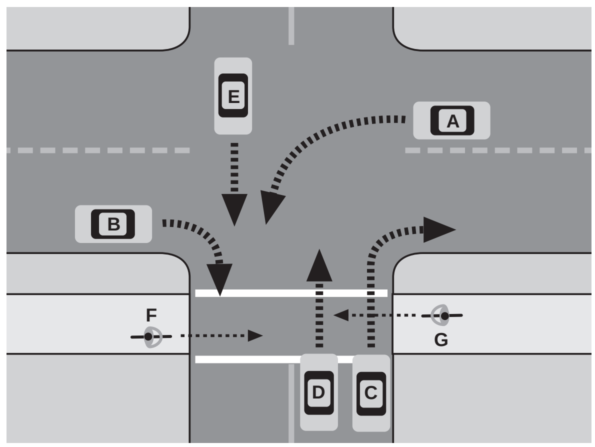


Figure 4-108: Possible conflicting turning and crossing movements that should be accounted for in an adjacent path crossing.

To some extent, the severity of these conflicts may be affected by how close the path is to the roadway it parallels. Generally, it is preferable if the path crosses the intersection relatively close to that road it parallels (fig. 4-105) unless the crossing may be located far enough away to minimize the intersection's impacts altogether. A location in between makes it harder for the path to take advantage of the intersection's traffic controls and makes it impossible to develop an independent crossing.

Consider the information in Table 4-11, based on information presented in the Florida DOT *Trail Intersection Design Handbook,* Table 3:

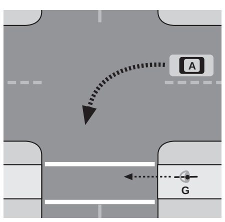
Table 4-11: Effects of path-roadway separation distance

Parameter	*<3.3 - 6.6 ft (1-2 m)*	*13.2 - 33.3 ft (4-10 m)*	*>99 ft (30 m)*
M. V. turning speed	Lowest	Higher	Highest
M.V. stacking space	None	Yes	Yes
Driver awareness of path user	Higher	Lower	High or low
Path user awareness of M.V.'s	Higher	Lower	Highest
Chance of path right-of-way priority	Higher	Lower	Lowest

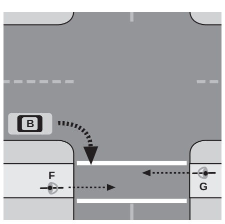
Figure 4-109: This path has few crossings and good visibility at this intersection. Even so, it is important to reduce conflicts between turning and crossing movements. A separate left turn phase for the bus, for example, could help.

4.15.5.1 Signalized parallel crossings

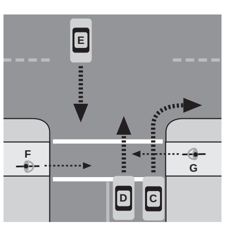
If the intersection in question is signalized, some basic modifications may be needed to reduce the hazards posed for path users. Simply introducing path traffic into an existing intersection without such modifications can lead to serious safety problems.



Left-turning traffic: For motorists turning left across the path (A), the primary danger is that they will not look for (or see) path users before making their turn. Prohibiting permissive left turns may be appropriate. A protected turn phase (with accompanying Don't Walk signal for path users) may be the best solution.



Right-turning traffic: For motorists turning right from the parallel roadway (B), the concerns are that they will fail to see and yield to path traffic. Reducing turning speeds or providing a “speed table” at free right turn lanes or making the corner turning radius as small as practical may be necessary to reduce conflicts.



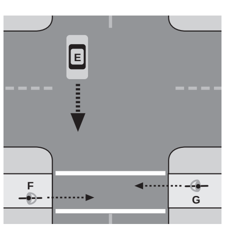
Side street traffic: For motorists pulling forward into the path crossing from the side street (C and D), the main concern is that they will do so without yielding or may wait in a position that blocks path traffic. Prohibiting right-turns-on-red and placing a stop bar in advance of the path crossing may help solve the problem. For motorists crossing from the far side (E), an adequate clearance interval should be provided for their green before the path’s Walk signal .

Figure 4-110: Positive features of this crossing are good visibility and proximity to the roadway intersection. Problems include lack of crosswalk marking and confusing right-of-way assignment (bicyclists apparently required to yield to motorists who have a stop sign).

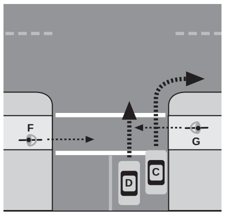
Figure 4-111: Some elements that would help include highlighting the crossing, moving the stop sign and stop bar for the crossroad, as well as adding appropriate warning signs (not shown). Still, motorists will tend to stop in the crosswalk to wait for traffic and the design is far from optimal.

4.15.5.2 Signed parallel crossings

Signed crossings provide additional challenges because certain movements may not be easily controlled (fig. 4-110). The primary principle to keep in mind is that the path should have the same priority as the parallel roadway (fig. 4-111). Some strategies mentioned in the previous section will be useful. However, the following additional points should be noted.



Far side crossing traffic: For motorists crossing from the far side (E), the primary danger is that they will not pay attention to path users. Path crossings should be as visible as possible with good sight distances on either approach. Raised crossings may be necessary to assert path priority where appropriate.



Nearside crossing traffic: For these motorists (C and D), the primary problem involves encroaching on and blocking the path crossing while waiting for a gap in traffic. As shown in figures 4-110 and 4-111, stop signs and stop lines for such traffic should be placed before the crosswalk, the crossing should be highlighted, and sight lines should allow motorists to see cross traffic from behind the crosswalk. Raised crossings may be necessary.

4.15.6 Important features of all crossings

The challenges — and opportunities — presented by a path/roadway intersection design can be complex and each solution is likely to be unique due to its combination of factors. But a well-done crossing can significantly enhance the path's utility and appreciation among users. In summary, for the safety and convenience of path users and roadway users, all path crossings should include the following features.

Figure 4-112: Warning devices let motorists know there is a path crossing.

Limited number of crossings: The more intersections a path has, the more frequently path users will have to deal with crossing traffic. It is important to limit the number of crossings and this may require a sober assessment of a potential path's suggested corridor or alignment.

Right angle crossings: Paths should meet roadways at right angles, rather than crossing at a skew. In this way, path users can easily see motor vehicle drivers and vice versa. In some cases (For example, where an old railroad right-of-way crosses a road at 45 degrees), a curve may need to be introduced to the path's approach alignment in order to create an appropriate crossing angle.

Crossing complexity: Path/roadway crossings should be designed to minimize complexity. Path users can be of virtually any age and, as a result, the simpler the crossing the better. For example, some parallel crossings require users to figure out which roadway traffic lanes get the green light, and when, in order to determine if it is safe to cross. And some crossings require motorists to guess whether they should stop for path users or cross. The level of difficulty of the path user's and road user's respective tasks must be a key factor in the design process.

Crosswalk visibility (fig. 4-112): Increasing crossing visibility with, for instance, enhanced crosswalk markings (fig. 4-96) can help all of these problems but, as mentioned elsewhere, the marking materials should not be slippery. Some communities have had success following the European example, providing colored crosswalk materials. This is not a standard treatment and must be done with special permission.

Crossing approach grade: Crossing approaches should be relatively flat in order to make stopping easier for bicyclists. Downgrades leading to a crossing in particular should be avoided. Braking to a controlled stop on grades can be especially challenging for casual bicyclists and children.

Good sight distances: Corner sight triangles must be kept clear of obstacles that might block the view between road users and path users. Bushes, signal controller boxes, light standards, and street furniture should not be allowed to interfere with this important requirement.

Clear right-of-way assignment: Confusion can easily lead to mistakes. And mistakes can lead to crashes. By making it clear who is required to yield at a crossing, designers can reduce that confusion, improve safety, and enhance a path's utility and comfort.

Ramp width and smoothness: Where the path enters the roadway, the curb ramp must be at least as wide as the path and should flare to the outside at the roadway interface. In addition, the transition must be smooth. A steep gutter pan that abruptly reverses slope or one with a lip will hamper wheelchair users and may trap them, unable to go one direction or the other. It will also cause some wheelchair users or bicyclists to stop or slow in the roadway as they negotiate the bump, resulting in increased roadway exposure.

Street lighting: Crossings should be well-lit so that path users can see approaching roadway traffic and, more importantly, so that roadway traffic can see path users. Pedestrians and wheelchair users are not required to use reflective material or lights; and bicyclists' lights may not provide adequate side visibility. See Section 4.13 for more on path lighting.

Figure 4-113: Near riverfronts, it is often possible for a “natural” grade separation to occur where roadways pass overhead. Adequate clearance must still be allowed for path users and maintenance vehicles.

4.15.7 Grade separations

A grade separation may be the answer if none of the at-grade intersection approaches will work — or if a path is particularly busy. Overpasses and underpasses each have their strengths and weaknesses (Table 4-12). And choosing one over the other requires balancing important factors.

One is the required grade change (up or down). The greater the elevation change, the longer the ramps must be (fig. 4-114) if they are to be kept to a proper slope (see Section 4.8). And to accommodate long ramps, more land must be found or structures must be built with switchbacks or a squared-off spiral design to gain or lose the required height. These issues may determine whether an overpass or underpass is feasible.

Figure 4-114: Overpass approach ramps are typically longer than ramps for underpasses and can significantly increase costs.

In addition, connections with the surrounding road network should be convenient and safe. While a grade separation may isolate path users from the immediate vicinity, many will want access to nearby land uses (e.g., restaurants, shops, schools) and nearby residents will want access to the path. To this end, connector paths must be carefully planned. Junctions must minimize hazards of introducing path users into the traffic environment. In some cases, paths may connect with low-volume residential streets.

Figure 4-115: A dark, damp, and uninviting underpass. In addition, the path entrance should be flared out to eliminate the path-side hazards.

For design information on grade separations, see the discussion on structures in Section 4.16.

Table 4-12: Overpass and underpass considerations

Overpasses

Positive:
- *Good visibility from surrounding area*
- *Light during the day*
- *Open and airy*

Negative:
- *Typically requires greater elevation change than underpass*
- *Bicyclists use energy to go up, gain it back coming down*
- *Open to the elements*
- *Vandals may drop or throw things onto road*
- *Some users may feel vertigo*
- *Bicyclists attain higher freewheeling speeds making ramps more difficult to negotiate and design*

Underpasses

Positive:
- *Protected from weather*
- *Bicyclists gain energy going down, lose it going up*
- *Change in elevation is likely to be less than with overpass*

Negative:
- *Can be dark, damp, and intimidating (fig. 4-115)*
- *Users may not be able to see through to other side*
- *Some users may feel claustrophobic*
- *Criminals may hide, waiting for path users*

Figure 4-116: A popular multi-use path structure connecting a university campus and nearby residential areas.

4.16 Shared-use path structures

Structures — overpasses, bridges, tunnels, and underpasses — can play critically important roles in shared-use path systems. While typically expensive, they can provide the linkages that tie a path network together. And since structures will likely to last for years, they should be built to serve future needs. Saving money by using inadequate bridge widths, for example, may provide a short-term cost savings but may mean the structure will quickly become obsolete.

Figure 4-117: An open and airy underpass. Note the generous clearances on either side.

Structures can reduce travel time by providing short cuts between destinations. Often, a path network that includes structures at key locations can give users a competitive advantage over motorists traveling to the same destinations. And, as mentioned in Section 4.15.2, structures can provide users with a safe way across major traffic corridors.

4.16.1 Bridges and overpasses

The following considerations apply to shared-use path bridges and overpasses:

Basic width: On new bridges or overpasses, the minimum clear width should be 12 ft (3.6 m), the desirable width is 14 ft (4.25 m). A bridge 12 ft wide provides for the basic path width of 10 ft (3 m) plus a 1 ft (0.3 m) clear zone on either side (fig. 4-118). Approach ramps should be as wide as the approaching path and the path's shoulder width should taper as necessary to match the bridge width.

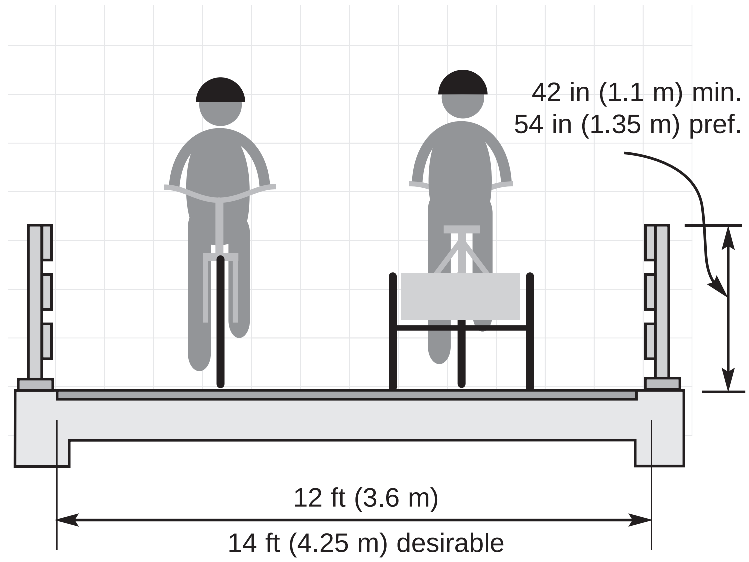


Figure 4-118: Bridge and overpass widths are measured between the railings.

Using such clearances in designing a structure serves two primary purposes:

- *it provides a minimum shy distance from the railing or barrier; and*
- *it provides maneuvering space to avoid conflicts with pedestrians and other bicyclists stopped on the bridge.*

Note: *The widths of common emergency, patrol, and maintenance vehicles should also be considered in establishing the widths of structures. If there is no other way for such vehicles to reach the other side or if the alternative route is much longer, these vehicle's widths should govern; for instance the WisDOT bridge inspection vehicle needs a minimum path width of 10 ft (3 m), preferably more, for it to properly use its boom to inspect the sides, supports, and undersides of the bridge.*

In some cases, providing a wider structure than suggested above can be justified. For example, a bridge that connects a college campus with a nearby residential area (fig. 4-116) may attract high volumes of users. Or the structure may provide an important entryway to the system. In some cases, a bridge may be widened in the middle to provide an overlook. This approach gives those who wish to enjoy the view a place to stand out of the traffic flow. And it may substitute for widening the entire bridge if volumes are not expected to be too high.

Figure 4-119: This bridge's width was limited by openings in the supports for the transit bridge above. It was further narrowed by angling railings inward.

Physical constraints may preclude providing adequate bridge width (e.g., a bridge may need to fit between existing supports as in fig. 4-119). In such cases, it may be necessary to provide a substandard bridge width but mitigation measures should be taken to minimize the hazard. Warning signs, extra sight distance at ends, and other elements may help.

Bridge railings: Railings, fences or barriers on both sides of a bridge or overpass are recommended to be 54 inches. This is especially important on highly elevated structures, high use facilities (particularly high-mixed use), or on long bridges. Railings, fences, or barriers shall be a minimum of 42 inches. There is a minor exception to this for an inside barrier when a path shares a bridge with a roadway. See FDM 11-35-1. Also, hand rails may be mounted 30 to 34 inches (0.75 - 0.8 m) above the deck.

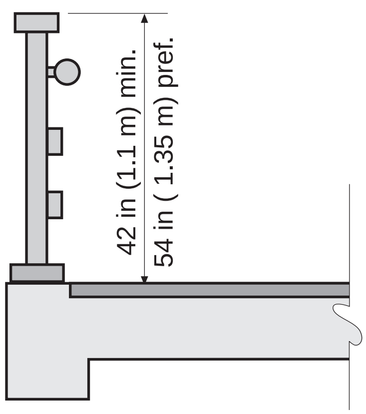


Figure 4-120: Railings should be high enough to prevent pitchover.

If the bridge is over a roadway or railway, protective screening or fencing may be needed to prevent users from throwing objects onto the facility below. Protective screening should be 9 ft (2.7 m) high with a 2.5 ft (0.75 m) radius curve over the path starting at 6.5 ft (2.05 m). It should also provide ample sight distances between the structure and the approach ramps.

Figure 4-121: A simple rub rail mounted at handlebar height can divert out-of-control bicyclists back onto the pathway.

Approach ramp railings; If the shoulders of the path approach slope away precipitously or if the ramp is raised above the ground, railings will be necessary for path user protection. Ends of railings should be offset away from the adjoining path to reduce the chance of cyclists running into them (fig. 4-123). If this is not possible, object markers, as described in the MUTCD (Part 9), should be used at the railing ends. See Section 4.5 for additional information on railings.

Approach ramp slopes: Ramp slopes should be minimized to the extent possible. This may be done by, for example, choosing a crossing with the least elevation change. For rural paths likely to have relatively little pedestrian or wheelchair use, the guidance found in Section 4.8 of this chapter should be used. For paths in urban and suburban areas or near popular recreational destinations, ramps should be designed according to the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG).

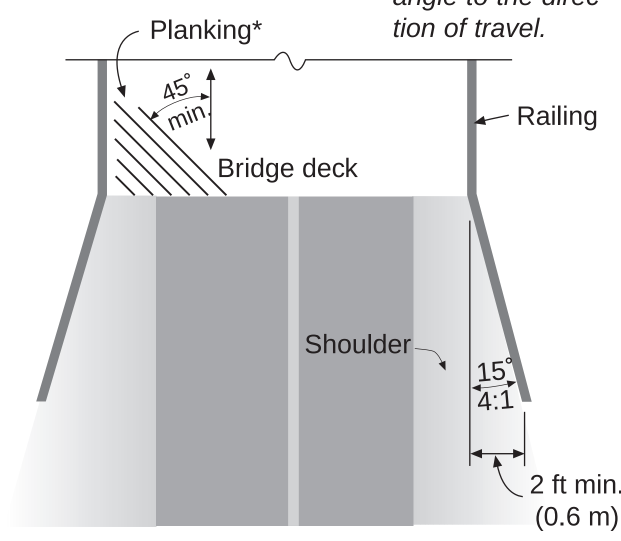
Figure 4-122: While this ramp provides landings and meets ADA slope limits, the overall length and height make it impossible to use for many disabled people.

To meet ADAAG, ramps should have a maximum running slope of 8.3%. Rises between level landings should be no greater than 30 in. (0.9 m). Landings should measure the full width of the facility and be at least 6 ft (1.8 m) long. Using numerous ramps to reach a high structure, however, will not serve the disabled well (fig. 4-122). In such cases, an elevator may need to be considered for high-use areas.

Bridge decking: On concrete bridge decks, expansion joints should be bicycle-safe and level with the deck. The deck should be broom finished or treated with a burlap drag to ensure a non-slippery surface. Metal decking may become slippery when wet or icy and is not generally appropriate for shared-use path bridges. Timbers may be used, but they should be laid crosswise — or at least 45° — to the direction of travel.

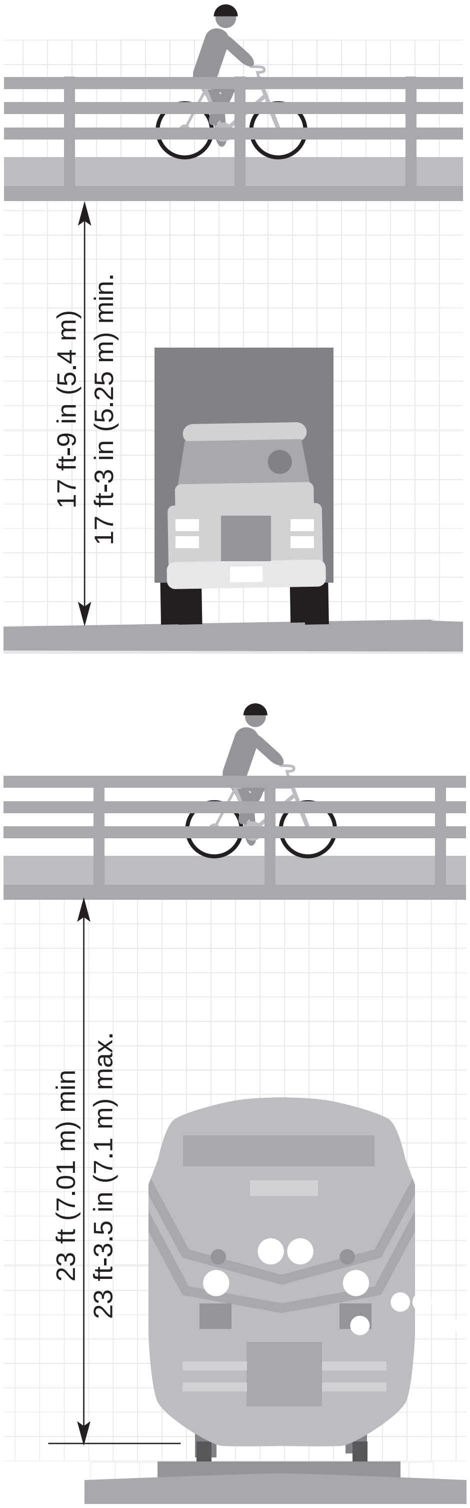
Bridge loading; Bridges should be designed for pedestrian live loadings. Where maintenance and emergency vehicles may be expected to cross the bridge, the design should accommodate them.

Figure 4-123: Bridge railings should flare away from the path entrance. Also, plank decking should be placed at no less than a 45° angle to the direction of travel.



**If planking is used, it must be laid at least 45° to the direction of travel.*

Figure 4-124: Adequate clearance is required for roadway and railway overpasses.



Vertical clearances: The superstructure of a bridge or overpass must provide adequate space for bicyclists to pass under. As mentioned in Section 4.5, there should be a minumum clearance of 8 ft (2.4 m) between the deck of the bridge and any overhead obstruction. However, maintenance and emergency vehicles requirements may govern.

If a structure passes above a roadway, clearances underneath must account for the heights of traffic using that roadway. According to Procedure 11-35-1 of the WisDOT FDM, the desirable clearance is 17 ft - 9 in (5.4 m) and the minimum is 17 ft - 3 in (5.25 m). See figure 4-124 (top). Although there is some variation, a structure passing over a railroad (fig. 4-124 - bottom) must provide a minimum of 23 ft (7.1 m) of clearance; the maximum suggested clearance is 23 ft - 3.5 in (7.10m).

Bridge lighting: While not as critical as underpass lighting, bridge lighting can serve an important purpose. Areas adjacent to river crossings, for example, may be quite dark and users will need to see other bridge users or potential hazard lying on the surface. Similarly, overpasses should be well-lit to discourage vandalism or the throwing of objects onto a roadway or railway. See Section 4.13 for more information on lighting.

Retrofitting old bridges

In many cases, a structure that can no longer serve motor vehicle traffic may be quite adequate for path use. Some bridges have been retrofitted in place, while others have been disassembled and moved to a new site. Some designers have even used old railroad flat cars as bridges over small channels.

In general, retrofitted bridges will provide more than adequate clearances and support for a path structure, although a structural analysis should be done. Some modifications to the decking, as well as new railings and additional pedestrian-level lighting, may be appropriate.

4.16.2 Underpasses and tunnels

The following considerations apply to shared-use path underpasses and tunnels:

Vertical clearances: A vertical clearance of 10 ft (3 m) should be provided for adequate shy distance, although 8 ft (2.4 m) is the minimum. Extra height, however, may be needed for official motor vehicles access needs. For example, the Wisconsin DNR generally uses 12 ft (3.6 m) for its trails to accommodate snow grooming equipment.

Figure 4-125: Careful design can result in an open underpass that is inviting to users.

Basic width: Widths of tunnels and underpasses should consider user comfort as well as physical requirements. Too narrow a structure may appear dangerous and forbidding and discourage users. As a rule of thumb, a height to width ratio of 1:1.5 works well. The minimum clear width should be 12 ft. (3.6 m), and 14 ft (4.2 m) is strongly recommended (fig. 4-126). In rare situations where an 8 ft (3.6 m) wide path is being used to connect to the underpass, a 10 ft (3 m) wide width can be considered. The 8 ft wide path (and the 10 ft-wide underpass) needs to meet the width conditions established earlier in this guide.

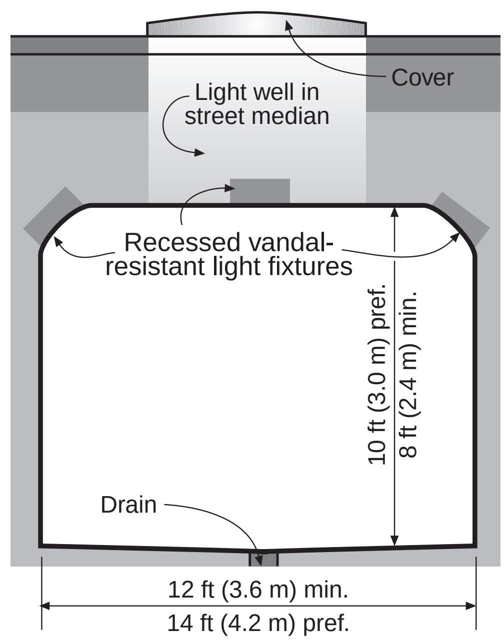


Figure 4-126: Standard dimensions and features for a shared-use trail underpass.

The designer must also strongly consider the land use and usage characteristics of where the path is to judge whether a wider underpass may still be necessary in the moderate to long run. Greater width may be justified in areas with many potential users. Ramps should be as wide as the approaching path and shoulder.

Where physical constraints prevent providing adequate width, mitigating measures should be taken. These include reducing the structure's length, providing better sight distances and lighting levels, and using advance warning devices.

Length: The longer the underpass or tunnel, the less inviting and more intimidating it will be. To the extent possible, finding an alignment that minimizes length helps to produce a safer and more comfortable structure for users.

Ramp slopes: Ramp slopes and lengths should be minimized to the extent possible. This may be done through careful choice of approach alignment and, in some cases, raising the roadway or other feature above. For rural paths likely to have relatively little pedestrian or wheelchair use, the guidance found in Section 4.8 of this chapter should be used. For paths in urban and suburban areas or near popular recreational destinations, ramps should be designed according to the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG).

Figure 4-127: With good sight distances and visibility through to the other side, this structure provides a comfortable passage for bicyclists.

Sight distances: Being able to see through a structure to the exit and beyond is an important consideration for user comfort and safety (figures. 4-125 and 4-127). To this end, approaches should align with the structure as closely as possible to increase sight distance and ramps should have gentle slopes, particularly near the bottom. Curves, where necessary, should occur well in advance of the entrance. And there should be no nooks or crannies within the structure to provide hiding places.

Flared entrances: Whenever possible, the sides of underpass and tunnel entrances should be flared to the outside for safety and to reduce the chance that a bicyclist may collide with the edge, as well as to improve visibility and interior light levels. Angles should be similar to those suggested for bridge railings (fig. 4-123).

Visibility and siting: The structure should be sited and designed for optimum visibility from nearby activity centers. This can help cut down on vandalism and increase user comfort and safety. At the same time, locating a structure near some land uses (e.g., bars and nightclubs) is generally not desirable.

Figure 4-128: This skylight, which comes up into the roadway median above, makes the underpass more inviting.

Natural light: Increasing the levels of natural light in an underpass can significantly improve its utility and attractiveness for users. This may be accomplished with widely flared openings and skylights in the middle of the structure (fig. 4-128).

Lighting: For short underpasses or tunnels, relatively modest lighting may be all that is required, particularly if natural light is enhanced through the measures discussed above. However, the longer the structure, the greater the need for illumination. For transition purposes and to highlight the entrance ramps, lighting should also be provided on approaches. All lighting should be recessed and vandal-resistant. See Section 4.13 for more information on lighting.

Wall and ceiling treatments: Underpass wall and ceiling colors should be light to minimize both the objective and perceived darkness of the structure. It may also help to have darker walls and ceiling near entrances with a transition to lighter shades near the middle. In addition, surfaces should be easy to clean, particularly for removing graffiti. Porous surfaces are undesirable and difficult to effectively clean.

Floor surface and drainage: The floor of an underpass should have the same characteristics required of path surfaces, in general. However, because of the potential for drainage problems, a surface that does not become excessively slippery when wet is important. Proper drainage is exceedingly important, since wet silt deposits are the most common hazards for bicyclists using an underpass.

Figure 4-129: This retrofitted barrier-separated path bridge shares an existing roadway bridge's structure.

4.16.3 Combining structures

Occasionally, an important path system barrier may be overcome by combining a shared-use path bridge with another structure. For instance, a path bridge over a river may be combined with a utility crossing (e.g., a sewer or water main), a railroad bridge, or a highway bridge.

In some cases, the two functions may be combined side-by-side (fig. 4-129) but in other cases, an over-under design works better (fig. 4-130). The choice of approach depends on a variety of factors, including:

- *available (and required) clearances (e.g., for waterway flood levels and boat traffic);*
- *load capabilities (particularly of existing structures); and*
- *the elevations of connecting facilities and the grades required to meet those elevations.*

When combining crossings, it is critical to protect the integrity and safety of each element. Highway (or railway) traffic, for example, must be kept separate from path traffic. The design should not violate the expectations of users of either element.

For instance, paths are often used by families with small children. To abruptly introduce these users into a highway environment would seriously compromise their safety. Similarly, most highway users would be unpleasantly surprised if they were suddenly confronted with young path users entering the roadway.

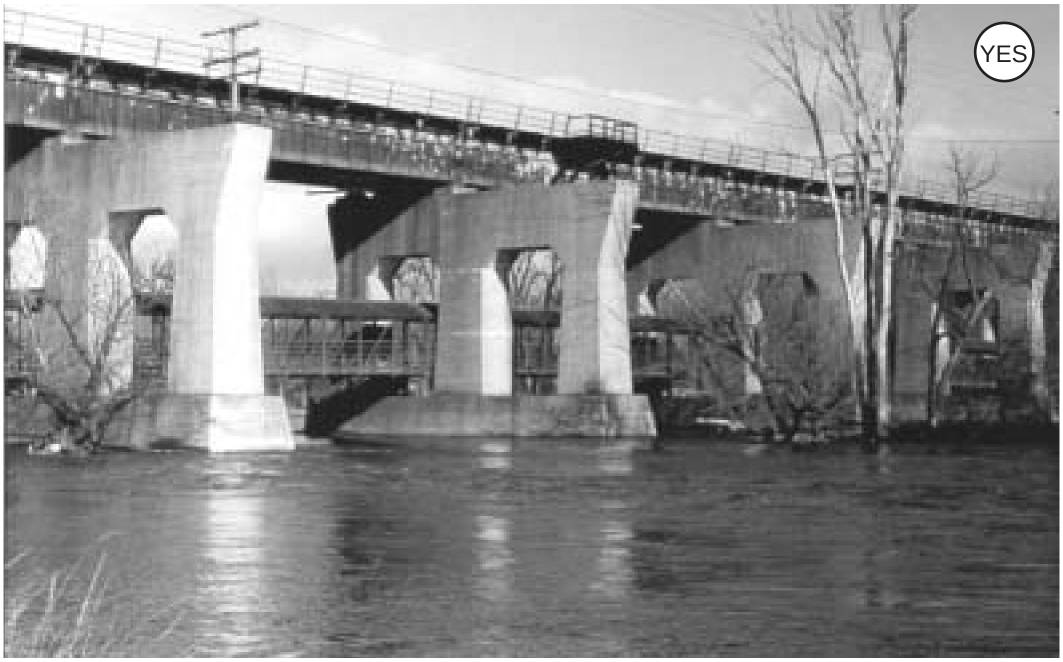
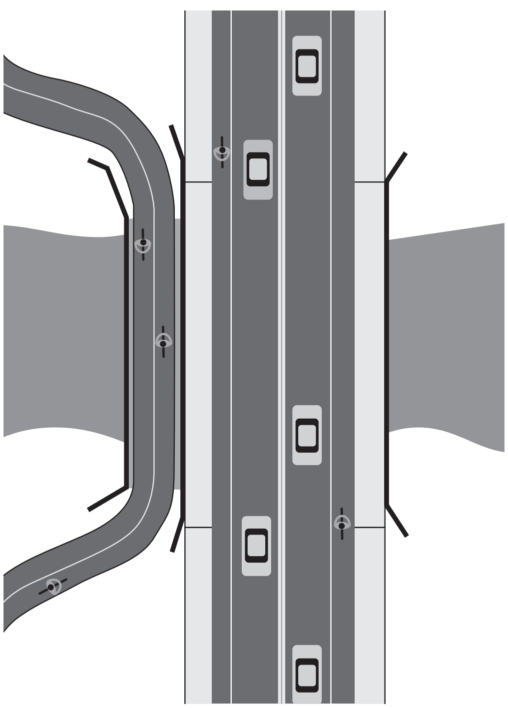


Figure 4-130: This path bridge spans a river under a railroad bridge. Attention must be paid to flood water levels and the river's navigability.

For these reasons, a separate path should not end at a roadway bridge, under the dangerous assumption that users will "find their way" across the structure. Continuity is an important safety factor.

Figures 4-131 and 4-132 show how a combined path/roadway bridge should work to keep the functions separate. Note that pedestrian and bicycle traffic related to the roadway corridor are provided for on the roadway bridge, itself.



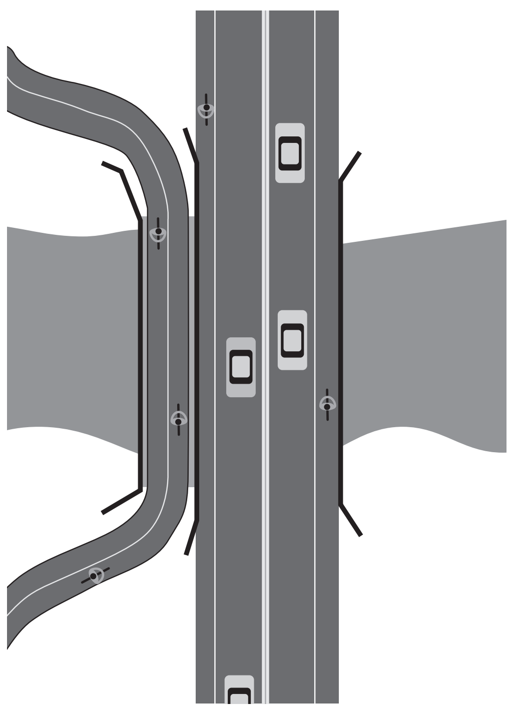


Figure 4-131 (left): A path/highway structure in an urban setting. Note sidewalk and bike lanes for pedestrians and bicyclists following the highway corridor.

Figure 4-132 (right): A path/highway structure in a rural setting.

By contrast, figure 4-133 shows the conflicts introduced when path users are directed onto a highway to use that facility's bridge. A similar problem is created when a separate bridge is provided for bicyclists using the roadway (fig. 4-134).

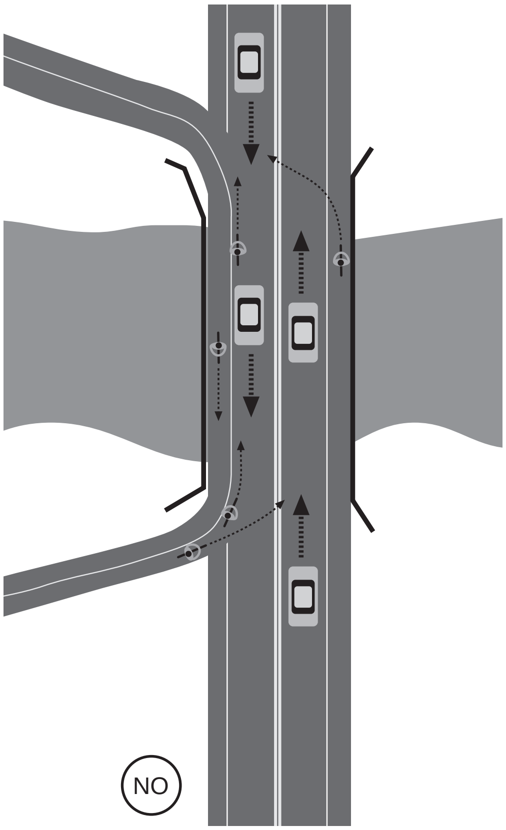


Figure 4-133 (left): Path users are directed onto a roadway bridge with unpredictable consequences.

Figure 4-134 (right): Roadway bicyclists are directed to a one-side bridge, also with unpredictable results.

Such designs are generally inappropriate. They require the bicyclist to choose between two risky options:

Crossing the highway twice at a potentially high-speed location. Such crossing maneuvers introduce unnecessary risk for path users and may surprise and unnerve highway users.

Riding against traffic. This also introduces risk — for the bicyclist traveling against traffic and for any bicyclists riding with traffic. In addition, it requires the bicyclist to break the law.

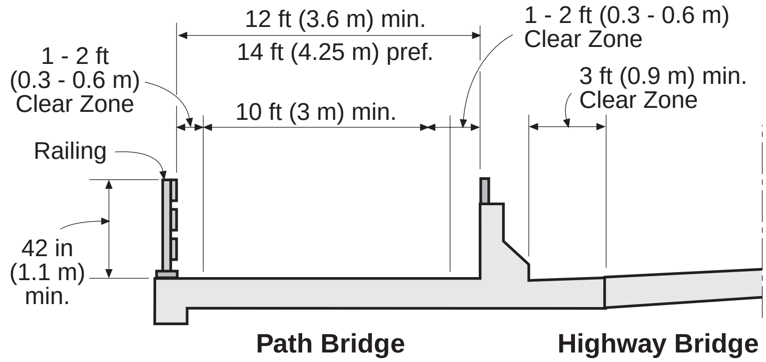
4.16.4 Separation on Combined Structures

A fixed barrier is very often required to separate path traffic and highway traffic on a combined path/highway bridge. At higher motor vehicle speeds (i.e., 45 mph and above), a positive barrier between the uses becomes a critically important safety feature. At lower speeds, a simple curb and wide sidewalk may suffice to separate the uses.

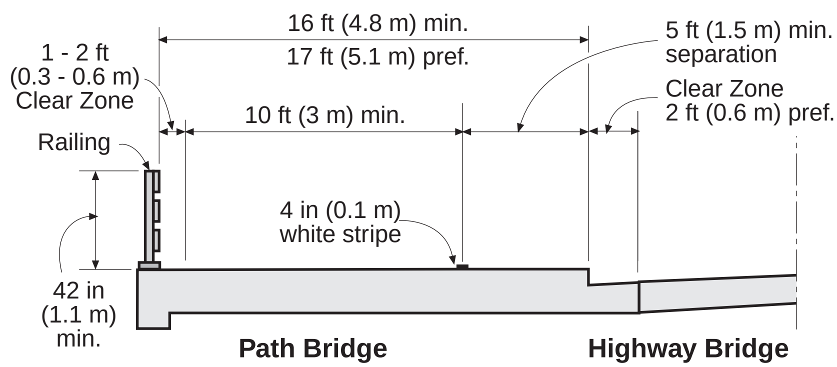
For low- and high-speed structures: Figure 4-135 shows a standard separation treatment. The sloped face type “F” parapet is used to separate the uses. A 54 in.-high (1.3 m) barrier is preferred, but a 42 in. (1.1 m) height can be used. Under exceptional circumstances, a 32 in. (0.8 m) barrier may be used. To attain the minimum height of 42 in. (1.1 m), a short section of fencing is added to the top of the parapet. In this case, a 1 ft (0.3 m) minimum clear zone is provided on the path side of the barrier.

For low- to moderate-speed structures only: Figure 4-136 shows the low-speed situation. By using the standard WisDOT raised sidewalk section with a 5 ft (1.5 m) separation, the path and roadway may be separated to a reasonable degree (see FDM 11-35-1). In this situation, the need for a clear zone on the sidewalk side of the path is reduced by the separation space and the low curb.

Alternative low- to moderate-speed structure option: As a third option for lower-speed situations, a median-type separating device could be used. The median should be 5ft (1.5 m) wide, but can be reduced slightly for low-speed (≤30 mph), low-volume roadways and where there is a shoulder or bike lane on the bridge deck which provides a significant clear zone between the median and the travel lane (fig. 4-137).

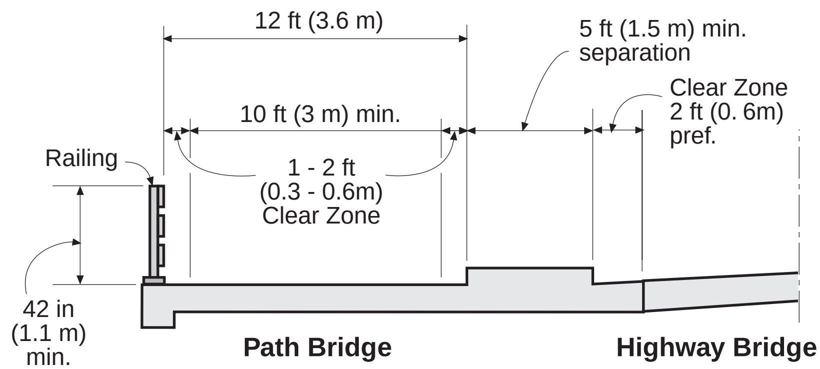


Combined Path/Highway Bridge with Barrier



Optional Combined Path/Highway Bridge

(Highway Speed Limit ≤45mph)



Combined Path/Highway Bridge with Median Separation

(Highway Speed Limit ≤45mph)

Figure 4-135 (top): Standard separation treatment includes a type “F” parapet.

Figure 4-136 (middle): An option for lower-speed roadways,

Figure 4-137 (bottom): Another low-speed option using a median separation.

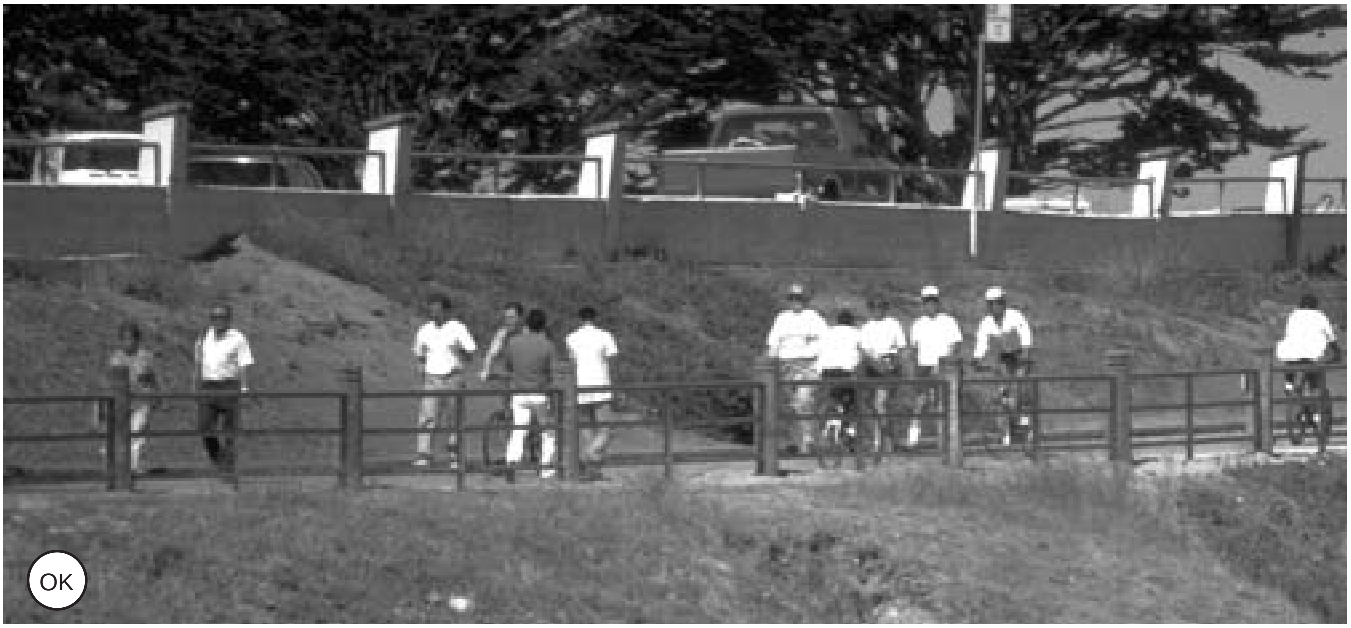


Figure 4-138: Most paths are shared-use, varying only in the mix between bicyclists and pedestrians. A busy path like this one may be a good candidate for separating bikes and pedestrians.

4.17 Shared Use

A typical shared-use path's traffic may include bicyclists, in-line skaters, roller skaters, roller skiers, wheelchair users (both non-motorized and motorized) and pedestrians (people walking alone or in groups, people with baby strollers or walking dogs, joggers, runners, and more). As a result, it is useful for the designer to look at the facility from a variety of user points of view.

For example, rest stops, benches, drinking fountains, and other amenities need not be too close together for bicyclists, most of whom can travel a mile in 4 to 6 minutes (10-15 mph). But for many pedestrians, walking a mile will take between 20 and 30 minutes. For this reason, amenities will need to be closer in areas where significant pedestrian use is expected or where senior citizens are more likely to be found.

And, while having a park bench right next to a path's edge would be little trouble for a pedestrian, it creates a serious hazard for bicyclists. At the same time, bicyclists may have little difficulty stopping for stop signs but roller skiers do not stop quickly. For them, a low-volume rural facility with gentle curves and few crossings or interruptions works best.

4.17.1 Pedestrians and Bicyclists

Many paths can operate acceptably under "shared bicycle-pedestrian use" conditions. This is particularly true of facilities that carry low levels of user traffic and/or where bicycle speeds tend to be limited. Paths that link popular destinations or that pass next to major generators (e.g., schools, parks, or college campuses) can become quite crowded and chaotic. In these situations, a shared-use design approach may break down.

Some communities have found separating pedestrians from bicyclists necessary on certain high-use paths. The following are examples of situations that may warrant separation:

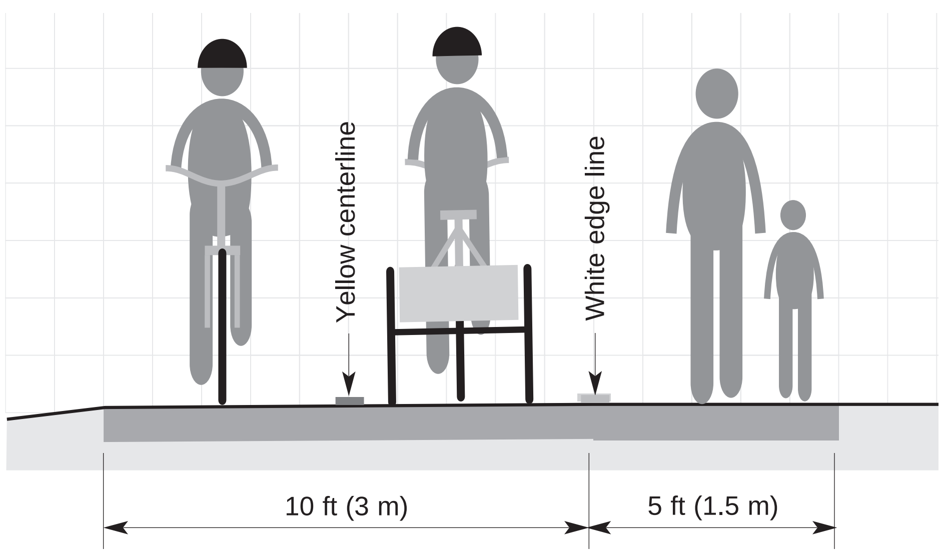
- *the route is used for fast bicycling (e.g., a commuter link to downtown or between a college campus and student housing) and passes close to a pedestrian traffic generator (e.g., an elementary school, restaurants, or office complex); and*
- *the route is largely contained within a park or urban riverfront with lots of potential pedestrian use and "exercise bicyclists."*

On some facilities, striping and signing may be used to separate bicyclists and pedestrians on one relatively wide path (fig. 4-139 and 4-140). However, this is not nearly as effective as physical separation, particularly with high pedestrian volumes, and extra width may be needed to accommodate all users. In addition, pedestrians like to walk side-by-side and talk and this often leads them to encroach on the bicycle part of the path. *(For striping and signing particulars, see Section 4.14.1.)*

Figure 4-139: One common way to separate bicycles and pedestrians on a shared-use path. Stripes only work well with relatively low pedestrian and/or bicycle volumes. For more on this, see Section 4.14.1.

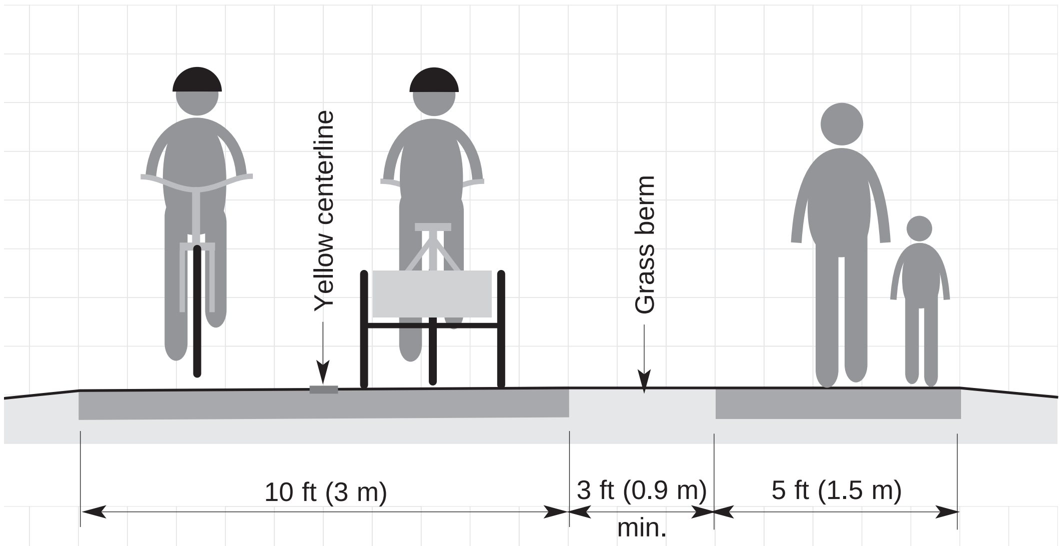
Such designs typically give more space to bicyclists, and pedestrians may find their relatively narrow lane unappealing, particularly if it means being passed by fast bicyclists at close quarters. On the other hand, bicyclists may find the pedestrian area inviting to use for passing other bicyclists. For these reasons, trying to separate users in this manner may not work.

Figure 4-140: Typical widths for a path divided by striping.



Path separated from walkway by edge line

Figure 4-141: Typical widths for a path divided by a grass berm.



Path separated from walkway by grass berm

Figure 4-142: This popular path splits into bicycle and pedestrian segments where space permits.

Physical separation is often preferable over striping (fig. 4-141). In numerous communities, it has been accomplished through the use of individual paths for “wheels” and “heels.”

Typically, wheelchairs and baby strollers go with “heels” while in-line skaters go with “wheels.” The physical separation is typically a 3 ft (0.9 m) or greater grass berm (fig. 4-142).

Figure 4-143: A maze intended to discourage motorcyclists. In general, anything that will keep motorcyclists off a path will make use difficult for bicyclists, tricyclists, and wheelchair users.

4.17.2 Motorbikes and motorcycles

Even where lawful, it is undesirable to mix motorbikes or motorcycles with bicycles and pedestrians on a shared-use path. Facilities funded through federal funds cannot allow motorized use, except where local ordinances permit snowmobile use. Electric motor bicycles and wheelchairs are also exempt, but most trail sponsors in Wisconsin still do not allow motorized bicycle use unless the engine is disengaged. In general, the mix of speeds and the noise introduced by motorbikes detract from non-motorized users' enjoyment of the path.

Numerous agencies have attempted to physically block motorcycles from paths through the use of various types of barriers (fig. 4-143). However, a barrier that keeps motorcycles out will make path use more difficult and potentially hazardous for bicyclists, tricyclists, wheelchair users, and pedestrians. Proper path management, including enforcement where necessary, is a more appropriate approach to solving such potential problems.

Figure 4-144: Enforcement is a better approach than barriers and it can help avoid other potential problems (e.g., assaults or robberies).

Figure 4-145: Often, nothing special is needed to discourage motorists from using a path.

Figure 4-146: Regulatory signs like the R5-3 should be used at path entrances if problems arise.

R5-3

4.17.3 Motor vehicles

In general, it is easier to keep motor vehicles off shared-use paths than it is to keep motorcycles off. Some practitioners find that motor vehicle barriers of any kind are seldom necessary (fig. 4-145). Motorists, as a rule, are not particularly attracted to driving on paths and they can be subtly discouraged from doing so. To help identify the intersection as a non-motorized path crossing, a number of elements should be considered.

Signing and marking: Signing and marking are common elements. The most common is the R5-3 No Motor Vehicles sign (fig. 4-146). Other elements include the W11-1 Bicycle Warning sign, marked crosswalks, D11-1 Bike Route signs with M7-5 directional arrows, and Bike Xing pavement markings. See Section 4.14.1 - 4.14.3 for more information.

Tight returns or curb ramps: Simple design features can also help discourage motorists from turning on to a path. For example, curbed

Figure 4-147: The bollard in the middle of this path entrance will not stop motorists from entering. It is, however, highly visible and has the appropriate pavement markings. Still, other elements should be the first choice to discourage encroachment.

entrances with tight return radii (fig. 4-148) of 5 ft (1.5 m]) can make path entrances less attractive to drivers.

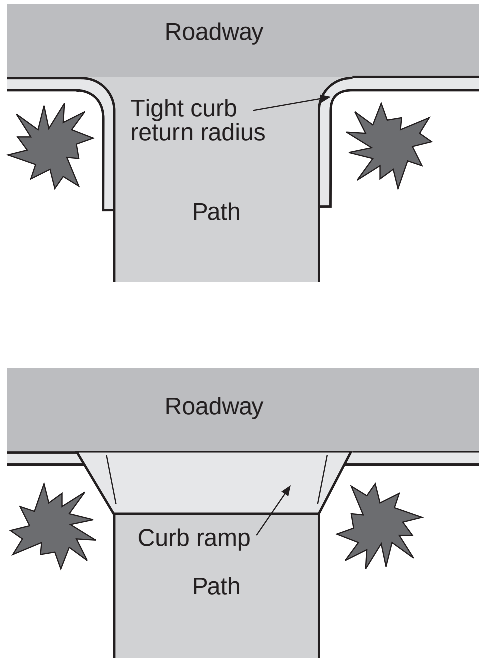


Figure 4-148: Two approaches to entrance design which can discourage most motorists from attempting to enter a shared-use path.

Similarly, curb ramps can discourage motorists. With the latter, it is important to make the transition between the roadway and the ramp smooth with gentle slopes on each side of the gutter pan.

Plantings; An additional measure to discourage motorists is low plantings on either side of the entrance. Low-growing shrubs that attain heights of 2 ft or so can visually narrow the path entrance and make motorists hesitate to try it. Fences that extend from the path area to the property line can also be used.

Split entrances: Another approach is to split the path entrance into two one-way paths near the intersection and provide a landscaped island in between (fig. 4-149 and 4-150). Low plantings can be used to discourage motorists from entering the path. These can be driven over by emergency vehicles but care must be taken to choose plants that will not grow tall, creating sight obstructions.

Figure 4-149: A split path entrance can, with proper low plantings, discourage motorists from entering.

Medians: A raised median with a cut-through can also help discourage motorists from turning into a shared use path (fig. 4-150).

While any of these measures may not keep all motorists from entering a path, they can significantly reduce the potential problem. And, in many cases, that is all that will be needed.

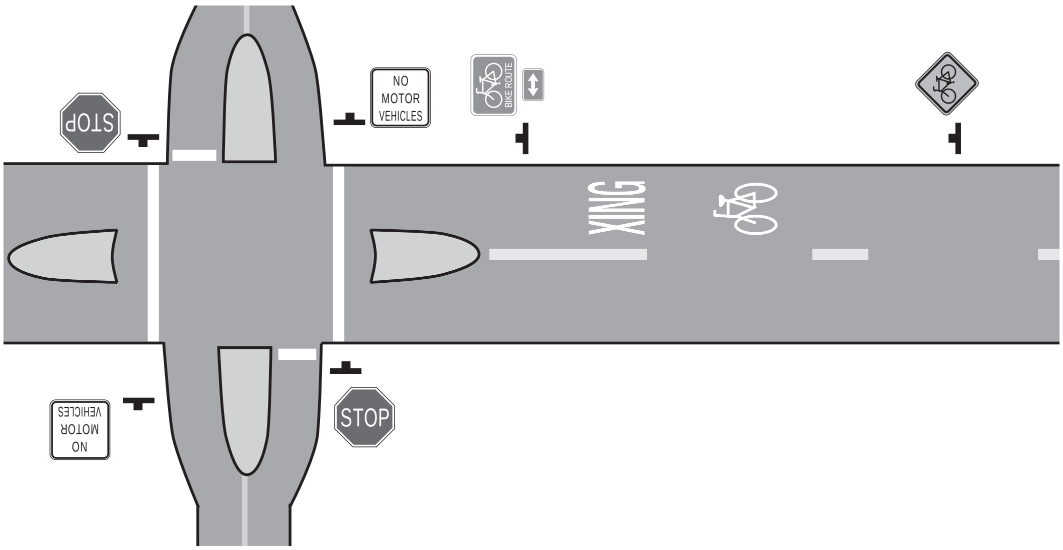


Figure 4-150: A split path entrance and/or a median on the roadway can discourage motorist intrusion.

If a problem with motorist use of a path arises, the first action should be to evaluate current design features and determine if there is a facility problem and whether it may be eliminated. It is also important to identify where and how motorists are getting onto the path, as well as whether there is a particular reason for such use.. For example, the path may provide a shortcut to an attractive destination (e.g., a fishing spot) or it may allow motorists to get around a barrier (e.g., a railroad line).

In addition, it may be possible to identify frequent users and target them for enforcement. In some cases, for example, a path may be used by a neighbor who knows it is wrong but finds the path a convenient shortcut. *[Often, path rules are self-enforcing, with bicyclists, pedestrians, and other neighbors taking the offender to task or contacting the police.]*

Once the situation is understood, proper design measures, as well as targeted enforcement steps, may be devised to stop the intrusion.

Figure 4-151: If bollards are necessary, they should be reflectorized, positioned in a highly visible location, and separated by 5 ft. (1.5 m).

Bollards: As a last resort, bollards may be considered (fig. 4-151). These should be reserved for locations with continual motorist encroachment where other approaches do not solve the problem. Since bollards can constitute a hazard and hamper maintenance, installations must be carefully designed.

If more than one is needed, three bollards should be used and must be spaced at least 5 ft. (1.5 m) apart to allow safe passage for bicyclists, adult tricycles, bicycle trailers, and wheelchair users (fig. 4-152).

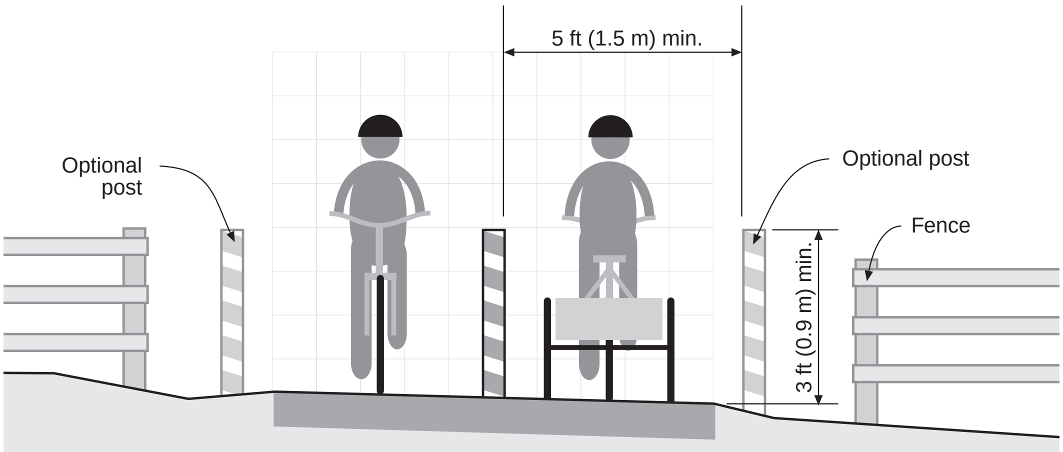


Figure 4-152: Reflectorized bollards must be at least 5 ft. (1.5 m) apart to allow bicyclists, tricyclists, bicyclists with trailers, and wheelchair users to pass.

Reflective pavement markings should be used to direct bicyclists away from the posts (fig. 4-58). Since bollards may be hard to see at dusk or at night, lighting is strongly recommended. Unlike the example in figure 4-153, bollards should be reflectorized for nighttime visibility and painted with bright colors for daytime.

Figure 4-153: Natural wood posts in unlit areas are hard to see.

Bollards should not be placed right at the intersection since they will distract bicyclists from looking for cross-traffic but should be set back beyond the roadway's clear zone. In this way, they will be close enough to the intersection to benefit from overhead lighting but far enough back not to constitute a distraction for bicyclists or a hazard for motorists.

Other barriers: If lighting is good, such things as decorative concrete garbage cans can serve as barriers (fig. 4-154). Because of their size, they are more noticeable than bollards.

Finally, separate gated entrances at key locations can provide a good solution for routine maintenance vehicle access. This can often work better than hinged or removable bollards, which can be damaged by abuse.

Figure 4-154: In well-lit areas, street furniture like decorative garbage cans can work better than bollards.

Fig. 4-155: Horses and bicyclists typically do not mix well on the same path Separation is important to path success. Visual barriers like bushes and trees are even better than fences, since the horses do not see the bicycles.

Figure 4-156: A bicyclist quietly passing these two horses from the rear could easily scare them.

4.17.4 Horses

Mixing horses and bicycles is not desirable on the same shared-use path. Bicyclists are often unaware of the need for slower speeds and additional operating space near horses. Horses can be easily startled if passed by a quiet bicyclist coming from behind (fig. 4-156). Proper trail etiquette is very important.

In addition, pavement requirements for bicycle travel are not suitable for horses. For these reasons, a bridle trail separate and, preferably, out of view from the shared-use path, is recommended (fig. 4-155). On lower-use rural paths, a separate bridle path several feet from the path's shoulder may work sufficiently well.

Figure 4-157 (right and left): Signs may be needed to identify appropriate corridors for pedestrians and bicyclists and horses.

Figure 4-158: Some paths are plowed while others are groomed for skiing or snowmobile use.

4.17.5 Cross-country skiers and snowmobiles

If a shared-use path is to safely accommodate bicyclists, pedestrians and wheelchair users in the winter, it needs to be relatively free of snow and ice. As a result, such a path cannot realistically be shared with snowmobilers (fig. 4-158). However, not all paths should necessarily be reserved for pedestrians and bicyclists.

Determining whether to plow paths or not should be based on a number of factors. These are some of the more important ones:

- *expected use by bicyclists and pedestrians;*
- *parallel options for bicyclists and pedestrians if the path is not passable; and*
- *state statute 81.15 regarding the liability for accumulation of snow and ice.*

For more information on maintenance issues and winter use, *see Appendix A.*

Figure 4-159: Lots of footprints and/or bicycle tracks in the snow are signs that a path should be plowed.